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A SURVEY OF AIR POLLUTION IN COMMUNITIES AROUND THE JOHN F. KENNEDY INTERNATIONAL AIRPORT, SEPTEMBER-OCTOBER 1964

Melvin Nolan

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

June 1966

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Air Pollution around John F. Kennedy International Airport

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

A SURVEY OF AIR POLLUTION

IN COMMUNITIES AROUND

THE JOHN F. KENNEDY INTERNATIONAL AIRPORT

September - October 1964

Melvin Nolan
Technical Assistance Branch
Division of Air Pollution

Details of illustrations in this
document may be better studied
on microfiche.

U. S. Department of Health, Education, and Welfare
Public Health Service
Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

June 1966

Cooperating Agencies

New York City Department of Air Pollution Control
Nassau County Health Department, Air Pollution Unit
New York State Air Pollution Control Board
Port of New York Authority
Queensboro Tuberculosis and Health Association
Queens Action for Clean Air Committee
Federal Aviation Agency
U.S. Weather Bureau
Public Health Service, U. S. Department of Health, Education, and Welfare

Review and Comments

Air Transport Association of America
Aviation Development Council

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Introduction

Prompted by complaints and public concern about the air pollution problem associated with jet-aircraft operations at John F. Kennedy International Airport, Commissioner Arthur J. Benline, New York City Department of Air Pollution Control, requested that the Public Health Service, Division of Air Pollution, initiate a study to evaluate the community air pollution problem attributable to aircraft operations. Recognizing the need to delineate the magnitude and extent of the problems associated with the increasing number of aircraft operations, the Public Health Service with the assistance and cooperation of several other federal, state, and local agencies conducted a limited air pollution study in the communities of Inwood, South Valley Stream, Rosedale, Springfield Gardens, and South Ozone Park, all surrounding John F. Kennedy International Airport.

A 1-month study was conducted during September and October 1964 that included an odor survey, measurement of gaseous and particulate contaminants in the atmosphere, an emission inventory, and analyses of flight operations, meteorological conditions, and public complaint records.

Because detailed information concerning contaminant emissions from jet engines was lacking, specific tracers could not be analyzed. Detailed knowledge concerning dispersion of contaminants from airborne moving sources is not presently available; therefore, the information in this report concerning the extent of the problem should be considered as tentative.

Summary and Conclusions

The data obtained in this limited 1-month study yielded the following information:

1. Limited measurements of particulate matter and hydrocarbons, and odor observations in the vicinity of J. F. Kennedy Airport yielded some evidence to indicate that aircraft operations contributed a small amount to particulate and hydrocarbon concentrations and to odor occurrence.

2. Concentrations of particulates, odors, and hydrocarbons at the sampling stations were substantial and came from many sources in the metropolitan area. Thus, the small variations that occurred in measured air quality were not significantly correlated to aircraft emissions on a statistical basis.

3. The number and percentage of jet aircraft using water injection during takeoff decreased markedly from 1963 to 1964 at the J. F. Kennedy Airport; therefore, smoke emissions caused by water injection have been reduced. This downward trend is expected to continue.

4. Meteorological conditions during the study were near normal for this period of the year. Poor conditions for atmospheric dispersion were experienced for a 5-day period; however, no prolonged severe atmospheric stagnation occurred. Therefore, we were unable to measure air contaminant concentrations that would exist under extremely adverse meteorological conditions.

5. The limited, modest studies reported herein did not show any difference in the characteristics of particulates emitted from jet, diesel, or gasoline engines.

Conduct of Study

A 1-month air-quality study was conducted in the communities adjacent to John F. Kennedy Airport in Queens and Nassau Counties, New York, from September 24 to October 24, 1964.

The study area was located essentially along the southwest shoreline of Long Island, New York (Figure 1). Jamaica and St. Albans are located on the northern boundary; and Valley Stream, Cedarhurst, and Inwood on the eastern boundary. The land is flat, is only a few feet above sea level, and is used mainly for residential, recreational, commercial, and small industrial establishments, as well as for the airport. Several major traffic arteries cross the area.

To evaluate the air pollution problem in these communities, especially those problems attributable to aircraft operations, eight sampling stations were located in the area. Atmospheric particulate samples were collected at six sampling stations, total atmospheric gaseous hydrocarbon samples, at one, and meteorological measurements were obtained at another station. The locations of the seven sampling stations are indicated in Figure 1. All sampling and observations were made within 3 miles of airport property.

An odor survey was conducted for two 1-week periods during October by an untrained observer corps comprised of about 100 junior high school students.

Meteorological data were obtained from the U. S. Weather Bureau Airport Station at the John F. Kennedy Airport and were analyzed by automatic data processing equipment at the Public Health Service Facility in Cincinnati, Ohio.

A questionnaire seeking opinions and experiences relating to air pollution conditions in the vicinity of airports serving other large cities was sent to air pollution authorities in 11 major cities in the United States. Their responses are presented to augment the data obtained in this study.

Trends in air traffic during the past 3 years at John F. Kennedy, as well as at the 11 other airports circularized, were analyzed. The shift from propeller to jets using water injection on takeoff to fan jets was related to the change in quantities and types of emissions.

Flight data from John F. Kennedy Airport were analyzed in detail for the period of the study. Runway use, flight patterns, and diurnal variation in jet and piston-type air traffic were determined.

Air pollution emission factors for various combustion sources were determined and particulate emissions from aircraft operations were compared with those from other sources.

The field investigation staff for the 31-day study consisted of one engineer from the New York City Department of Air Pollution Control; one sanitarian from the Nassau County Health Department Unit, Air Pollution; one meteorologist from the U. S. Weather Bureau Research Station; and two chemists from the Division of Air Pollution, Public Health Service. The Public Education and Information Office of the Queens Tuberculosis and Health Association assisted in establishing an agreement with New York City Public School officials in the Borough of Queens permitting selected junior high school students to participate as untrained observers in an odor survey. The Noise Abatement Office of the Federal Aviation Agency and the Port of New York Authority supplied data on aircraft operations and aircraft fuel use. The New York State Air Pollution Control Board provided air sampling instruments used for measuring atmospheric particulates.

Measurements of atmospheric hydrocarbons were made by the laboratory of the New York City Department of Air Pollution. The particulate sampling project, odor survey, and emission inventory were conducted jointly by the Air Pollution Section of the Nassau County Health Department and the Public Health Service. The data produced on strip charts by the automatic recording hydrocrabon analyzer were integrated on an hourly basis and tabulated on data forms by means of a semi-automatic device. The data obtained with nonrecording samplers were tabulated on data forms, and these data and those produced from the strip chart records were then key punched manually onto cards for use in an electronic digital computer programmed to file and store the data on a master magnetic tape, and produce tables of raw data and final reports (correlations, means, standard deviations, percentage frequency distributions, etc.). Data obtained in the odor survey were card-punched and analyzed with a card sorter.

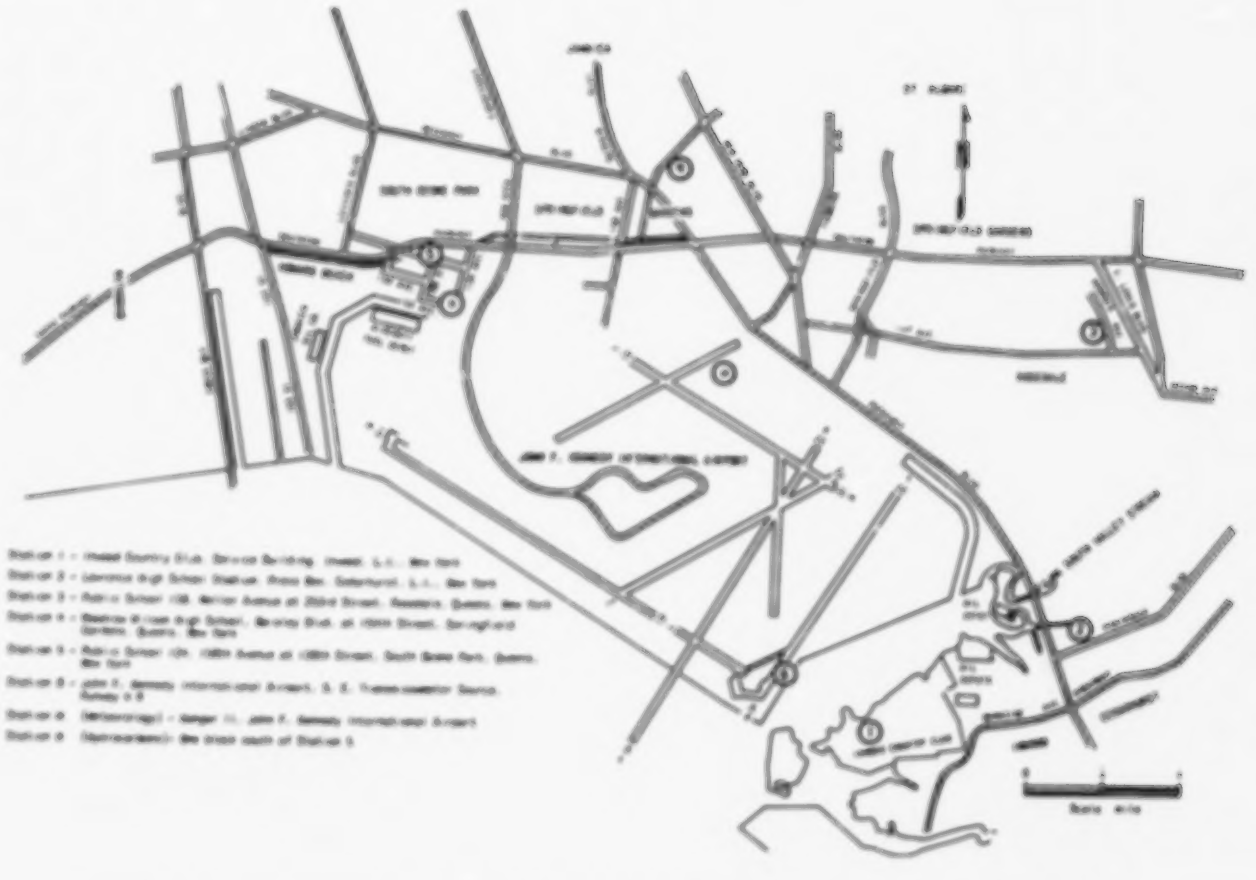

Figure 1. Air sampling stations in vicinity of John F. Kennedy International Airport.

Discussion of Results

PARTICULATE POLLUTANTS

Two methods were used to estimate atmospheric suspended particulate pollutants: soiling index as measured by light obscuration of filtered samples, and total suspended particulate loading on a weight basis.

Soiling Index

Soiling index was used for (1) estimating the amount of atmospheric suspended particulates of small particle size that caused decreased visibility owing to light scattering and absorption, and (2) estimating the capability of particulates in the atmosphere to cause soiling of walls, furniture, drapes, and buildings. The values were recorded in cohs* per 1000 linear feet of air. Air samples were drawn through a sequential filter-paper-tape sampler, and the reduction in light transmitted through the filter paper as a result of particulates collected over a 2-hour sampling period was recorded.

Soiling index data for three stations are presented in the Appendix (Tables A1 to A4). Data obtained at each sampling site are summarized in Table 1. The data were also summarized by use of an adjectival rating system adopted by the New Jersey Department of Health (Table 2).

Table 1. SUMMARY OF SOILING INDEX VALUES (cohs/1000 ft)

Station No.	Range	Arithmetic mean	Geometric mean	Median	Maximum 24-hr average
1	0.1-4.7	1.0	0.7	0.8	1.9
4	0.1-5.0	0.8	0.5	0.6	1.8
5	0.1-5.0	1.1	0.8	0.8	2.1

The greatest average concentration occurred at station 5 located northeast of the airport in South Ozone Park; the concentrations at all sampling sites did not differ markedly, however. The highest frequency of occurrence of soiling index values of 2.0 and greater also occurred at station 5, i.e., 13.2 percent (Table 2).

*One coh unit is the quantity of particulate matter that produces an optical density of 0.01 on filter paper.

Table 2. FREQUENCY OF OCCURRENCE OF SOILING-INDEX VALUES

Station number	Range, cohs/1000 linear feet of air	Rating[a]	Frequency of occurrence, %
1	0 - 0.99	Light	70.0
	1.0 - 1.9	Moderate	20.0
	2.0 - 2.9	Heavy	5.0
	3.0 and greater	Very heavy	5.0
4	0 - 0.99	Light	72.5
	1.0 - 1.9	Moderate	18.9
	2.0 - 2.9	Heavy	4.6
	3.0 and greater	Very heavy	6.0
5	0 - 0.99	Light	60.6
	1.0 - 1.9	Moderate	26.2
	2.0 - 2.9	Heavy	7.2
	3.0 and greater	Very heavy	6.0

[a] Based on adjectival rating system of the State of New Jersey. A strict interpretation of this system would classify values 4.0 and greater as "extremely heavy". The data in that classification were incorporated in the "very heavy" rating.

In Figure 2, the average diurnal variations of soiling index during the 1-month study period for sampling sites 1, 4, and 5 are compared with the variations that occurred during a 3-day period when conditions for atmospheric dispersion were poor. Greatest soiling values at the three stations occurred from 0600 to 1000 hours, which is coincident with peak automobile traffic hours and also a large number of jet departures (Figure 3). However, during the hours when the greatest number of overall flights (jet landings and departures (Figures 3 and 4), and prop landings and departures) occured, namely, between 1500 and 2300 (Figure 5), soiling index values were average or below average at all three sampling sites. This indicates that soiling index values cannot be specifically related to pollution emissions from aircraft operations.

The relationship between soiling index and wind direction at stations 1, 4, and 5 is shown in Figure 6. Station 1, located southeast of the airport had an average of 1.0 cohs, and greater-than-average concentrations during calms and when the wind direction was southwest through west to northwest. Greater-than-average soiling index values were recorded at station 4, located north of the airport, during calm wind conditions or when the wind direction was west through northwest to north. At station 5, located northwest of the airport, greater-than-average concentrations occurred during calm and when the wind direction was southwest and west. Figure 7 shows soiling index versus frequency of occurrence.

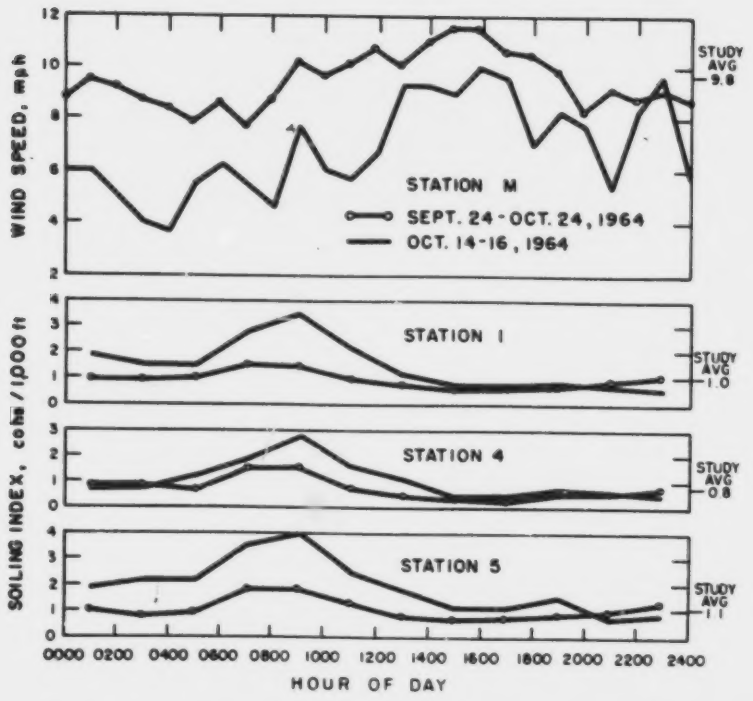

Figure 2. Average diurnal variation of wind speed and soiling index.

Particulate pollution as measured by soiling index was greatest at stations 4 and 5, when the wind direction was upwind of the airport. A possible exception to this may be station 1, where the greatest concentrations occurred with a wind direction of west, and the next greatest concentration occurred with a wind direction of northwest. Station 1 is downwind of the airport when the wind direction is northwest and may be considered partially downwind when the wind direction is west.

To determine if pollution originating at the airport contributed significantly to pollution measured at station 1, parallel samples collected at stations 1 and 5, when the wind direction was southeast and northwest, were compared (Table 3). Stations 1 and 5 lie in a northwest - southeast axis on either side of the airport. Analysis by the paired "t" test showed no significant difference in mean concentrations. These data indicate that aircraft-exhaust particulates emitted at ground level or directly above airport property did not contribute significantly to suspended particulate concentrations in the surrounding communities represented by stations 1, 4, and 5. Whether particulate emissions during climbout or landing contributed measurably to atmospheric particulate concentrations near the ground

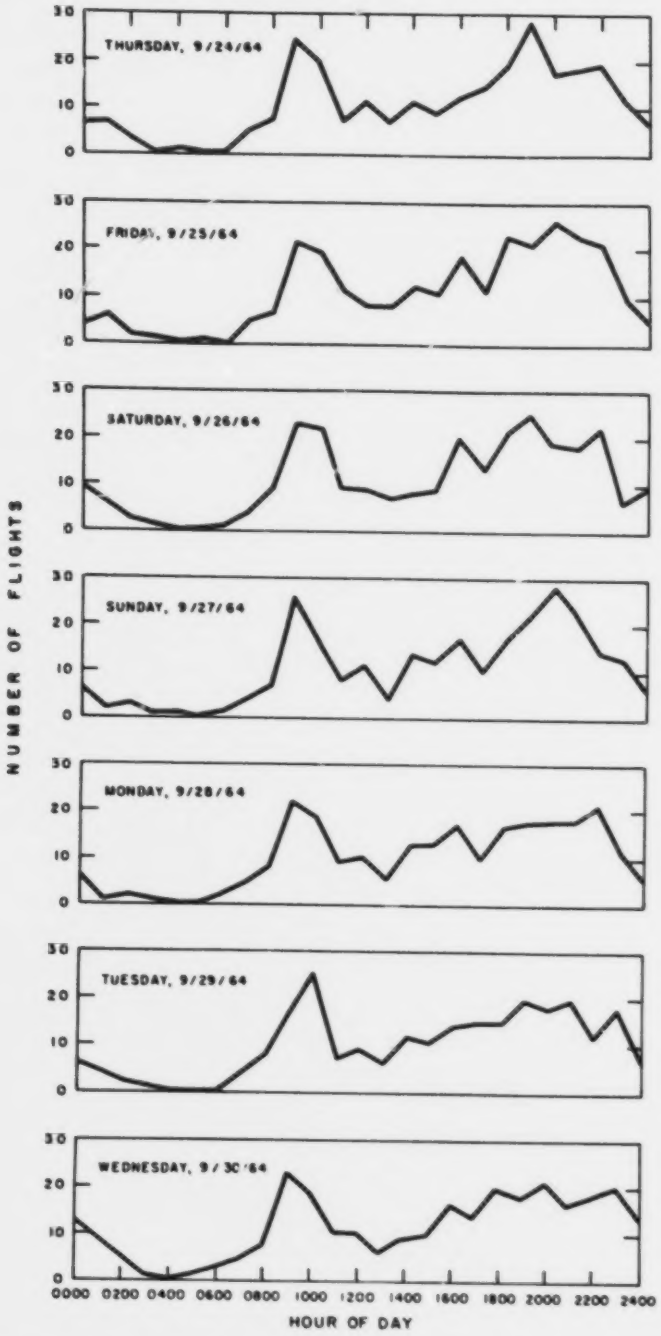

Figure 3. Diurnal variation in number of jet departures.

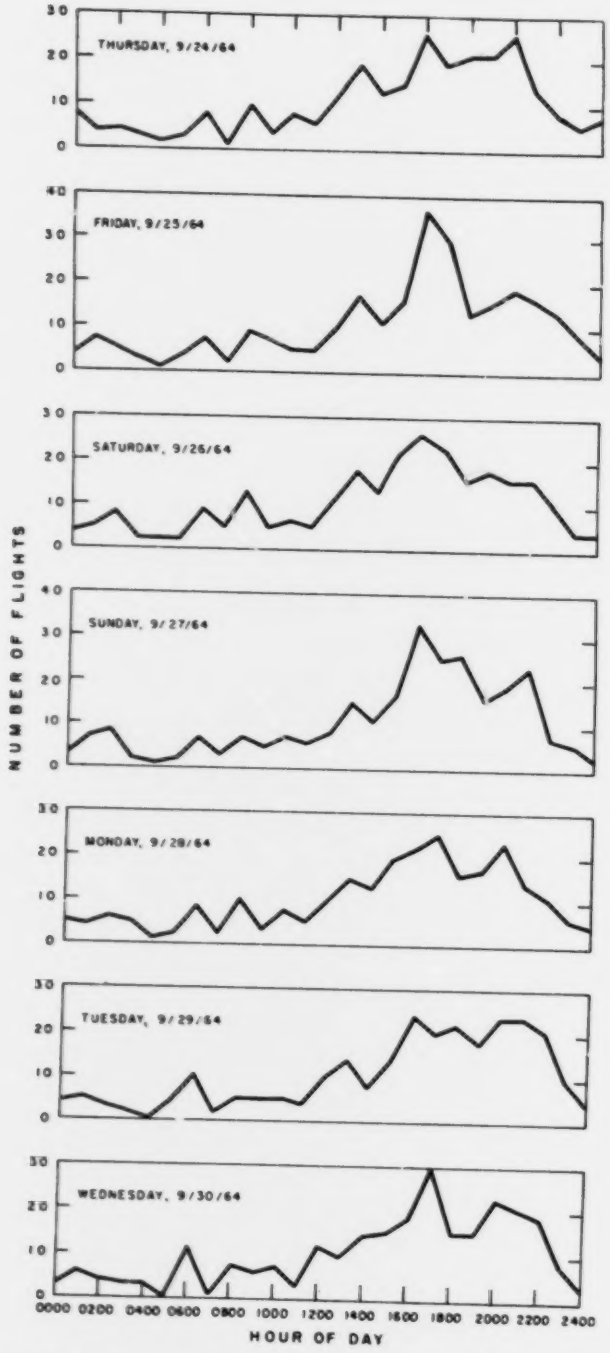

Figure 4. Diurnal variation in number of jet arrivals.

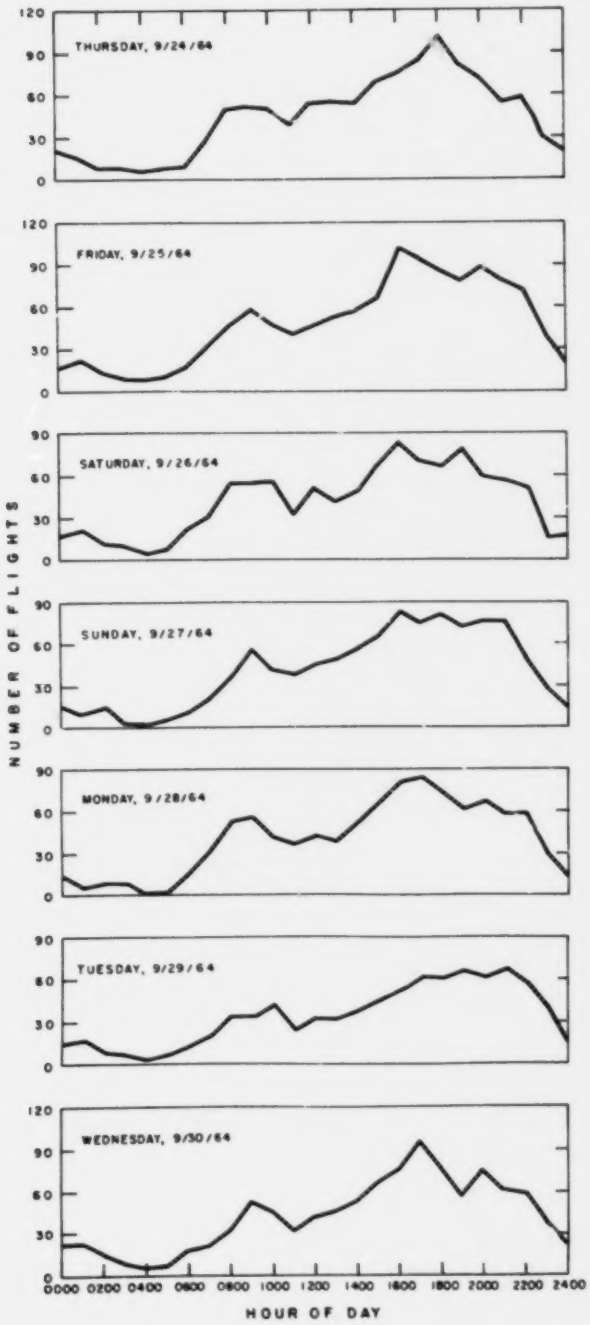

Figure 5. Diurnal variation in number of flights.

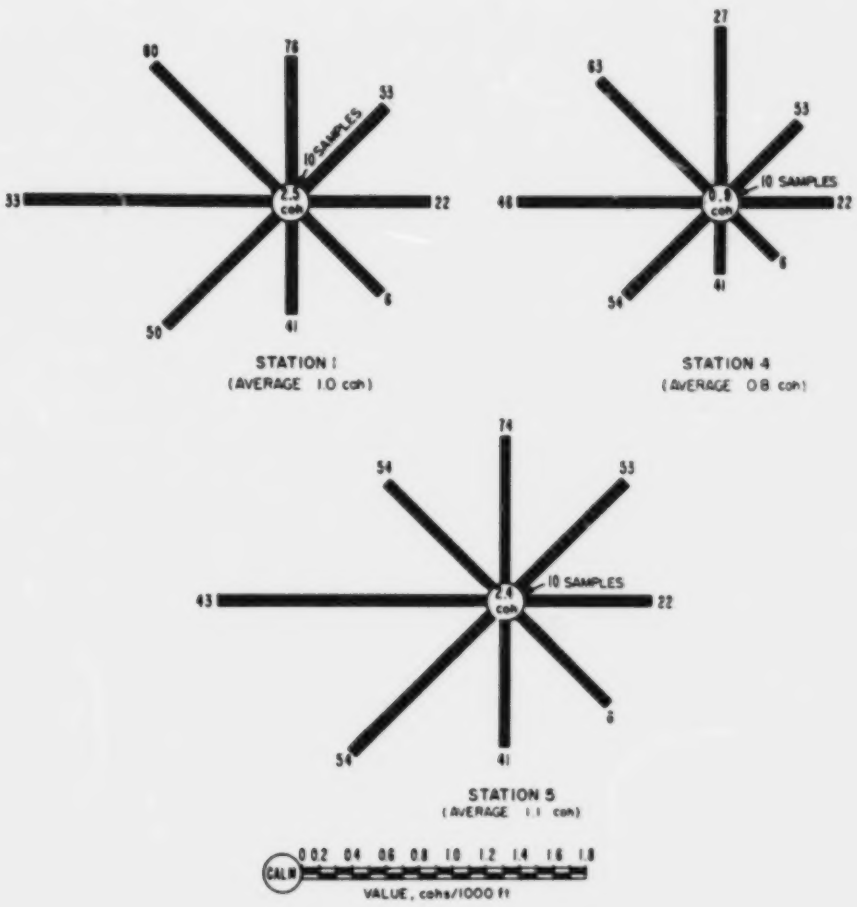

Figure 6. Variation in soiling index values with wind direction. (Numbers at end of direction radials refer to number of 2-hr samples.)

could not be determined since the measurements obtained were not characteristic of jet-exhaust particulates alone, and the dispersion pattern of pollutants discharged from a moving source above ground was not known.

Total Suspended Particulates

Particulates in the atmosphere arise from combustion of fuels, industrial processes, wind erosion, and other sources. The daily average atmospheric particulate loading was determined on a weight basis from integrated 24-hour samples obtained by high-volume filtration through glass-fiber filters.

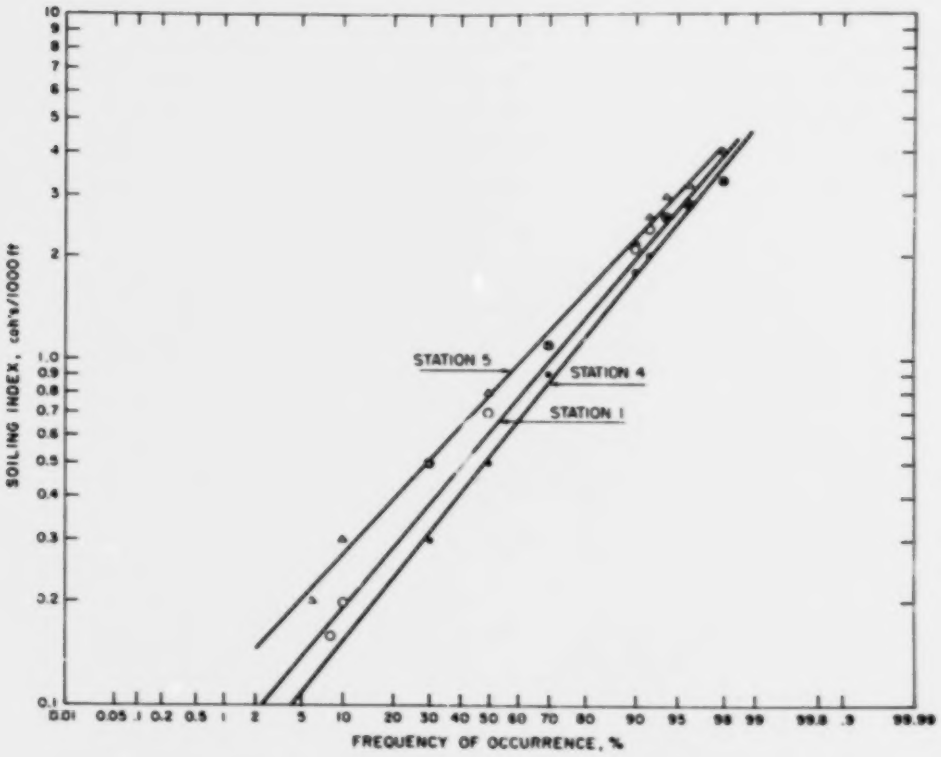

Figure 7. Cumulative frequency distribution of soiling index values.

Table 3. COMPARISON OF SUSPENDED PARTICULATE CONCENTRATIONS UPWIND AND DOWNWIND OF J. F. KENNEDY AIRPORT (Sept. 24-Oct. 24, 1964)

Wind direction[a]	Arithmetic mean, cohs/1000 ft			"t" test for significant difference in means at 95% confidence level
	Station 1	Station 5	N[b]	
SE	0.7	0.8	6	No difference
NW	1.0	0.9	60	No difference
All wind directions	1.0	1.1	351	

[a] Station 1 is downwind at a wind direction of NW.
Station 5 is downwind at a wind direction of SE.

[b] Number of paired samples.

Greatest average concentrations were measured at station 5, located northwest of the airport, and the lowest at stations 6, 1, and 2, located southeast and east of the airport (Appendix, Table A5). The relationship between 24-hour suspended particulate concentrations and wind direction is shown in Figure 8. A prevailing wind direction was assigned if the specified wind direction prevailed 12 or more hours out of 24 hours; otherwise, for purposes of analysis, the wind direction was

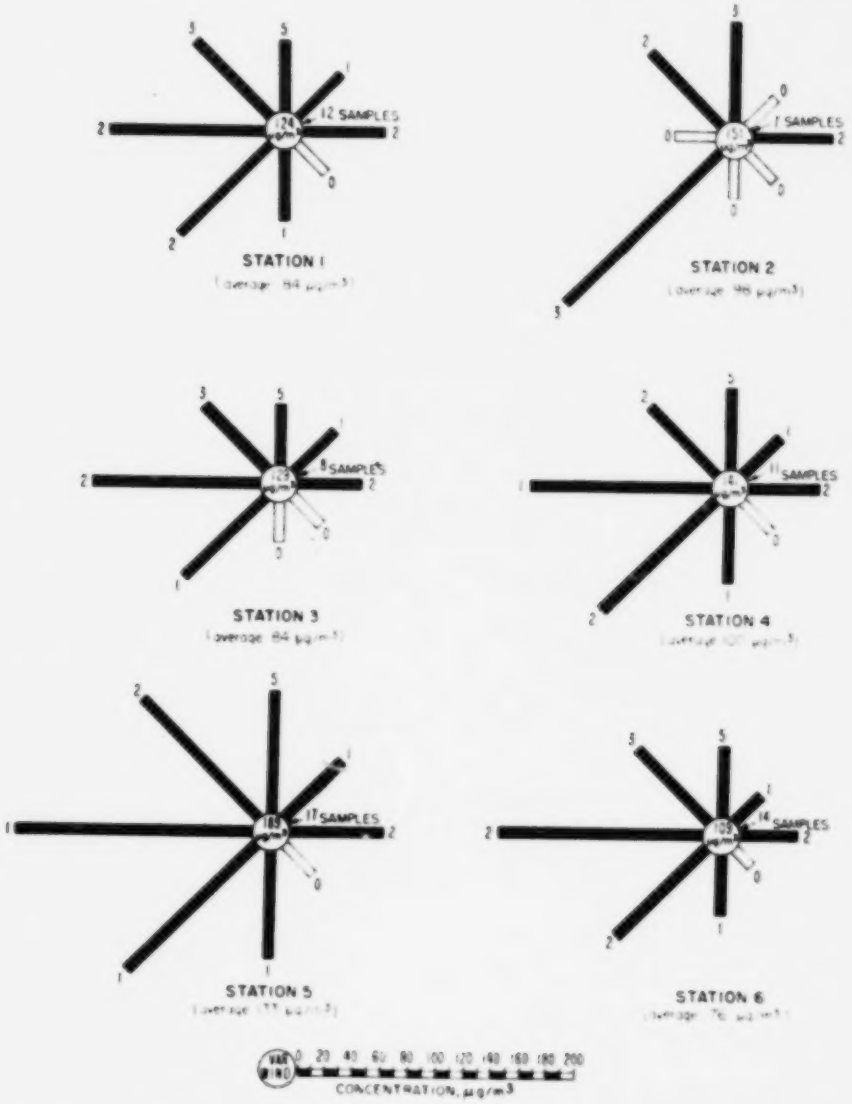

Figure 8. Variation of suspended particulate concentration with wind direction. (Numbers at end of direction radials refer to number of 24-hr samples.)

considered variable. At every station, greater-than-average concentrations occurred when the wind direction was west, southwest, or variable. These data suggest that particulate sources located in the immediate study area, such as the airport, did not contribute substantially to higher-than-average particulate pollution levels; however, they do indicate that particulate pollutants emitted from sources located west and southwest of the study area did contribute significantly to these levels. Station 5 and stations 1 and 6 lie in a northwest - southeast axis on either side of the airport when the wind direction is northwest. Analysis of parallel samples on the 2 days (October 19 and 22, 1964) when the prevailing wind direction was northwest showed considerably greater concentrations at station 5 than at stations 1 and 6, which indicates that airport sources of particulates are not appreciable when compared to sources located northwest of the airport. There were no days with a wind direction of southeast; particulate pollution concentrations were smallest at these stations when the wind direction was northeast, east and south (Figure 8).

The cumulative frequencies of occurrence of suspended particulate concentrations for the six sampling sites are shown in Figures 9 and 10.

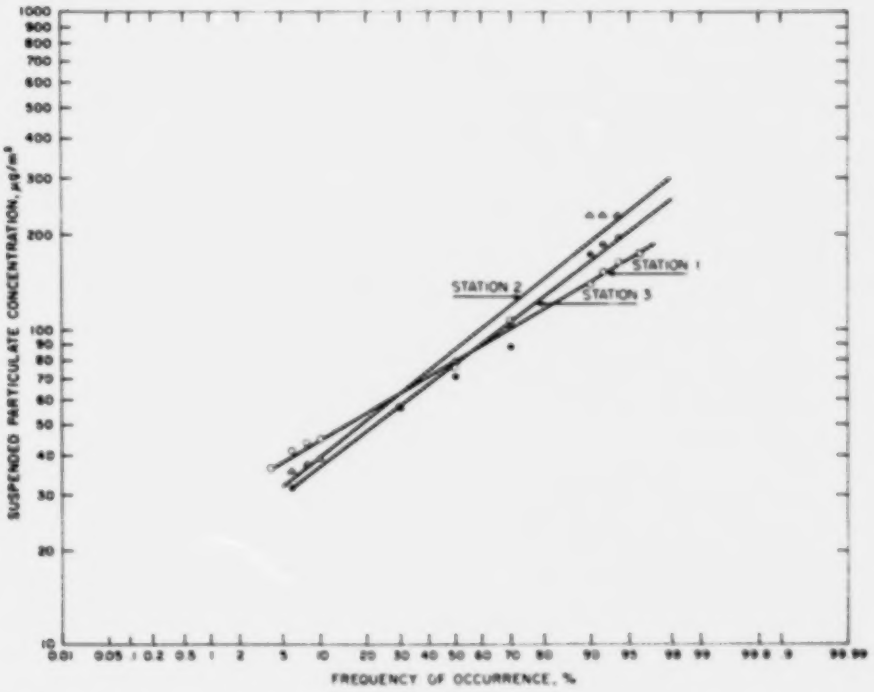

Figure 9. Cumulative frequency distribution of suspended particulate concentration at stations 1, 2, and 3.

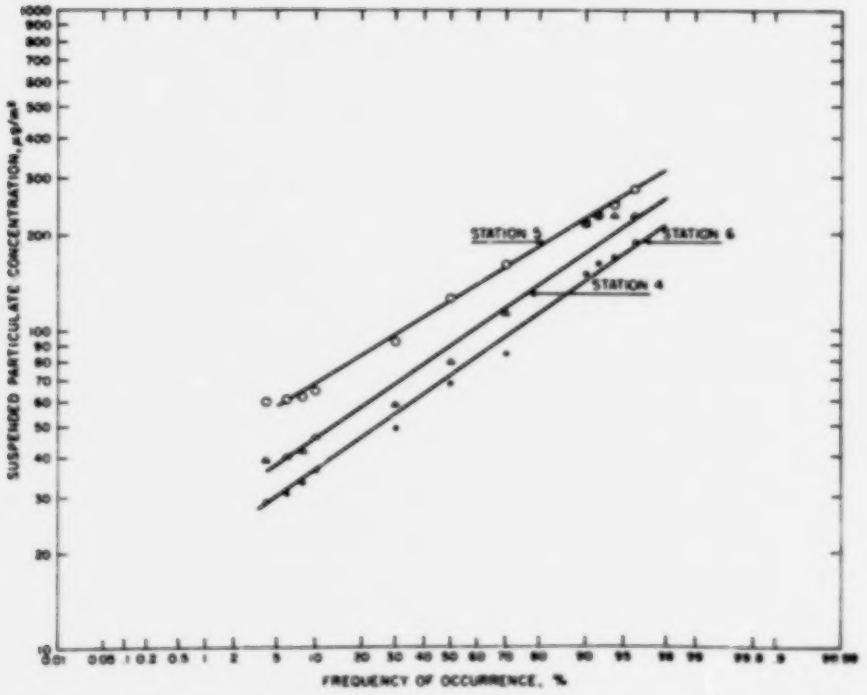

Figure 10. Cumulative frequency distribution of suspended particulate concentration at stations 4, 5, and 6.

Benzene soluble material in atmospheric particulate samples was determined on several samples collected at each site. Greatest average benzene soluble concentrations occurred at station 5, located northwest of the airport, and the lowest at station 6, located at the southeast corner of airport property (Table 4). The average percentage composition of organic material in particulates was greatest at stations 3 and 4 located northeast and north of the airport. The average atmospheric benzene soluble concentration (14.8 $\mu g/m^3$) is well above the national urban average (9.9 $\mu g/m^3$) and is about the same as the average for New York City (14.4) (Harlem Court House Building on East 121st Street, Manhattan), which indicates there are appreciable concentrations of atmospheric organic particulates in the area.[23]

Table 4. COMPARISON OF BENZENE SOLUBLE MATERIAL PRESENT AT SIX SAMPLING SITES

Date	Measurement	Station number					
		1	2	3	4	5	6
10/13	A. Total particulate, $\mu g/m^3$	175	230	202	202	236	153
	B. Benzene soluble, $\mu g/m^3$	25.1	25.8	29.4	25.5	27.7	17.6
	$\frac{B}{A}$, %	14.3	11.2	14.6	12.6	11.7	11.5
10/14	A. Total particulate, $\mu g/m^3$	158	208	183	193	287	165
	B. Benzene soluble, $\mu g/m^3$	11.3	14.2	16.8	19.5	30.6	12.8
	$\frac{B}{A}$, %	7.2	6.8	9.2	10.1	10.7	7.8
10/21	A. Total particulate, $\mu g/m^3$	86	208	84	84	133	67
	B. Benzene soluble, $\mu g/m^3$	3.8	14.2	6.1	6.6	8.4	4.0
	$\frac{B}{A}$, %	4.5	6.8	7.3	7.9	6.3	6.0
10/22	A. Total particulate, $\mu g/m^3$	76	-	68	70	130	82
	B. Benzene soluble, $\mu g/m^3$	5.6	-	6.2	6.2	10.6	8.7
	$\frac{B}{A}$, %	7.4	-	9.1	8.9	8.2	10.6
Average	A. Total particulate, $\mu g/m^3$	134	216	134	137	197	117
	B. Benzene soluble, $\mu g/m^3$	11.5	18.1	14.6	14.5	19.3	10.9
	$\frac{B}{A}$, %	8.4	8.3	10.1	9.9	9.9	9.5

Characterization of Engine Exhausts

To characterize particulate emissions from jet engine exhaust, particulate samples were collected at the end of and beside the runways at Greater Cincinnati Airport and at John F. Kennedy Airport by means of greased glass slides, gummed paper, and porcelain dishes. Samples were also collected perpendicular to the exhaust of jet, diesel, and gasoline engines, by use of gummed paper and greased glass slides. No unique particles were observed in the jet exhaust sample or in the samples collected along the runways. Additional samples of jet, diesel and gasoline engine exhaust were collected on filmed electron microscope grids and were examined with the electron microscope. Several of these samples were submitted to McCrone Associates for examination and identification. Photomicrographs of various samples are shown in Figures 11, 12, and 13. It was concluded that the source of engine exhaust particulates could not be definitely identified with the resources available in this study.

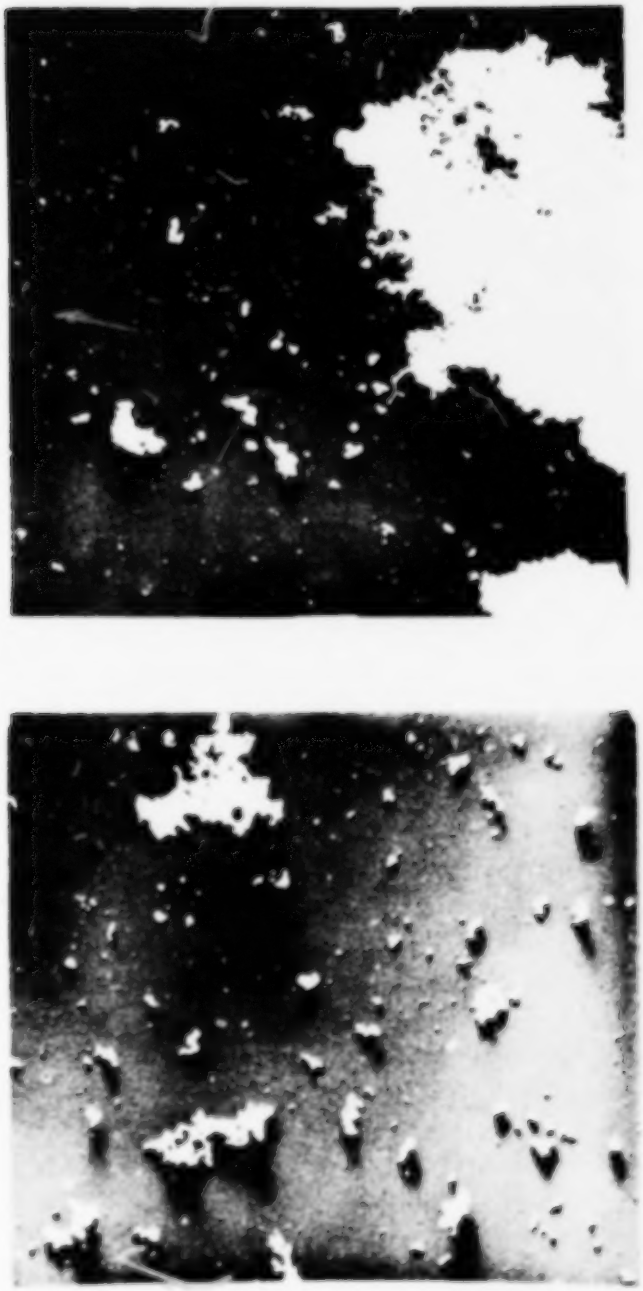

Figure 11. Electron micrographs (18,000X) of particulates emitted from an automobile engine; idling (top); racing (bottom). (By Walter C. McCrone Associates.)

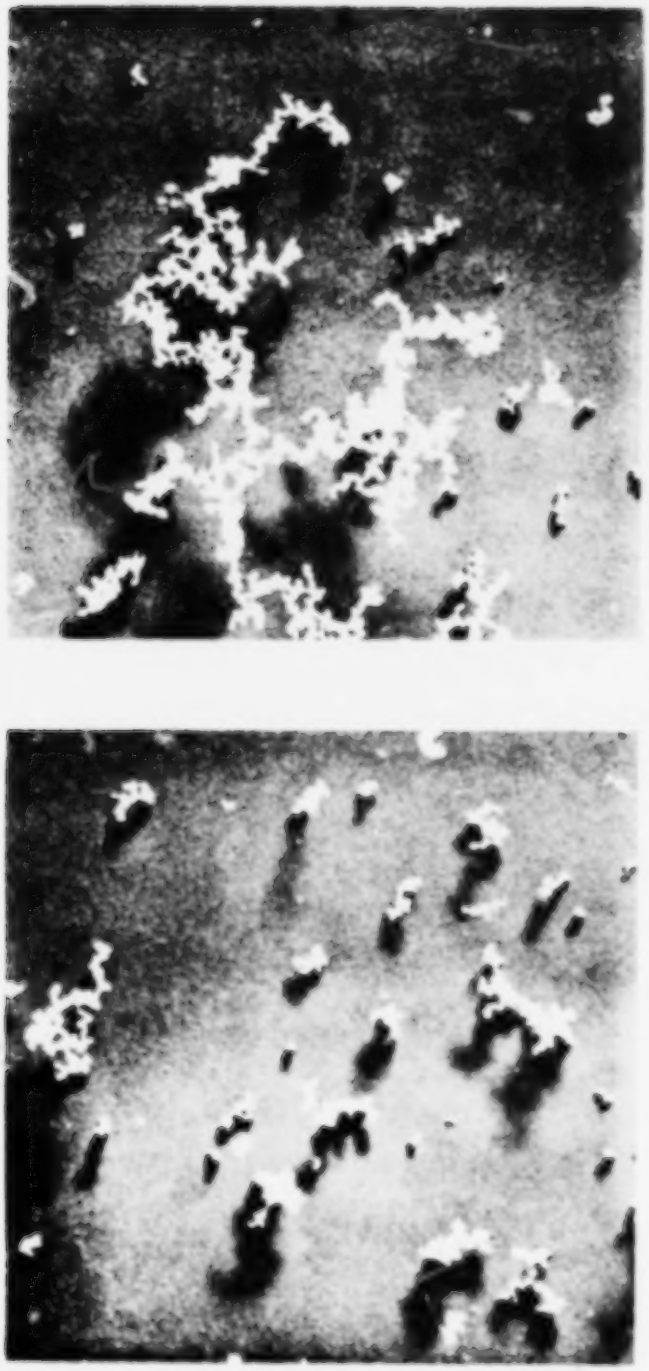

Figure 12. Electron micrographs (18,000X) of particulates emitted from a diesel engine; idling (top); racing (bottom). (By Walter C. McCrone Associates.)

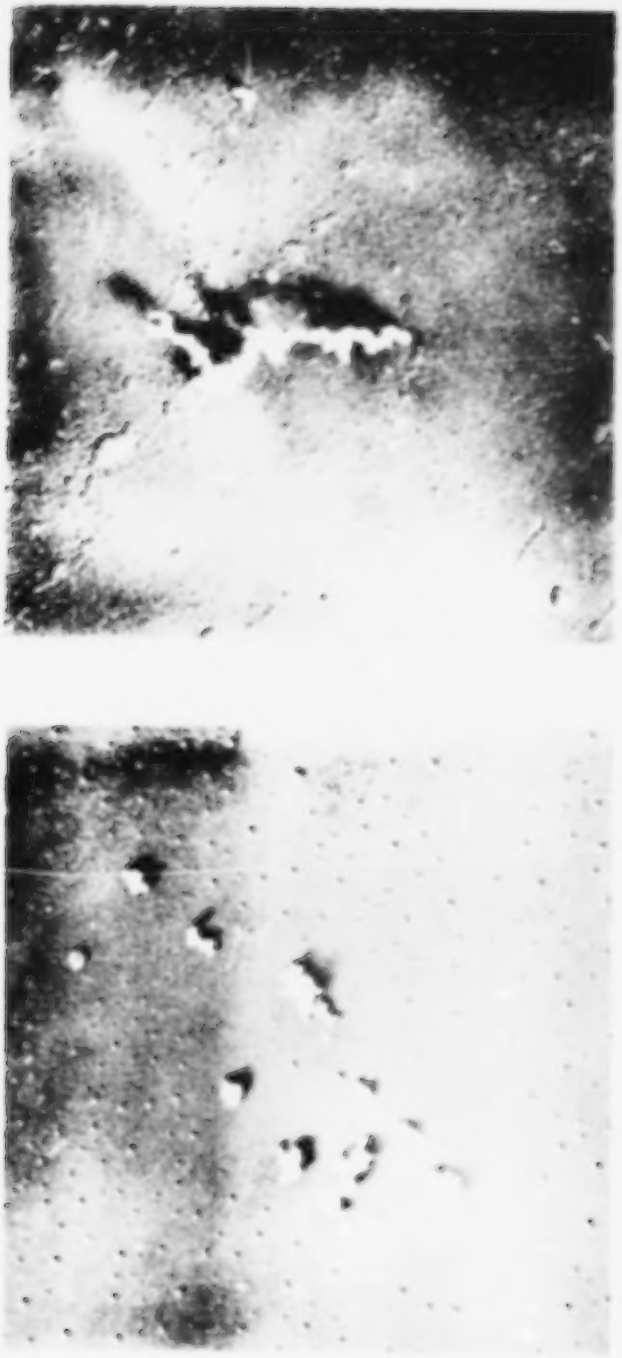

Figure 13. Electron micrographs (18,000X) of particulates emitted from a jet engine. (By Walter C. McCrone Associates.)

VISIBLE POLLUTION FROM JET AIRCRAFT TAKEOFFS AT JOHN F. KENNEDY INTERNATIONAL AIRPORT

The 12-picture sequence shown in Figure 14 illustrates typical visible pollution emissions during takeoff from an aircraft powered by turbofan jet engines. After takeoff and at the beginning of the climbout stage (an altitude of about 500 feet) the smoke trail decreases markedly, but is still perceptible to the naked eye. In comparison, the 12-picture sequence in Figure 15 illustrates typical pollution emissions from an aircraft powered by turbojet engines with water injection (used for additional thrust on takeoff from a standing start to an altitude of approximately 500 feet). The smoke cloud behind the four-engine aircraft is much more dense and obliterates the horizon behind the aircraft. As the aircraft traverses the runway, the buildings opposite the runway are lost from sight as one looks perpendicular to the moving smoke plume. A dense smoke cloud persists near the ground for about 2 minutes after the starting of takeoff (last picture in this sequence).

GASEOUS POLLUTANTS

Total Hydrocarbons

Total atmospheric hydrocarbon concentrations were measured continuously with an automatic monitoring flame-ionization hydrocarbon analyzer and the data were integrated and reported on an hourly basis. The analyzer was located about three blocks off the northwest corner of airport property and one block south of station 5 in South Ozone Park (Figure 1). Hourly average hydrocarbon concentrations ranged from 2 to 20 ppm, (Appendix, Table A6). The minimum amount detectable by this method was 2 ppm. The arithmetic and geometric means were 3.4 and 2.9 ppm, respectively. The cumulative percent frequency distribution of hydrocarbon concentrations is given in Figure 16. Greatest average concentrations usually occurred during calms and with prevailing winds from the west and southwest (Figure 17), and during the hours between 0300 and 0600 and between 2000 and 2400 (Figure 18). Hydrocarbon concentrations varied inversely with wind speed and, in general, varied directly with soiling index values, except that hydrocarbon concentrations were relatively higher than soiling index values during the evening and lower than soiling index values during the morning. The time of occurrence of the evening maximum hydrocarbon concentrations is coincident with periods of the greatest number of jet aircraft operations (Figures 3 and 4). To determine if the hydrocarbon concentrations measured from September 24 to October 24, 1964, at station H during the hours of 2000 to 2300 were influenced mainly by aircraft

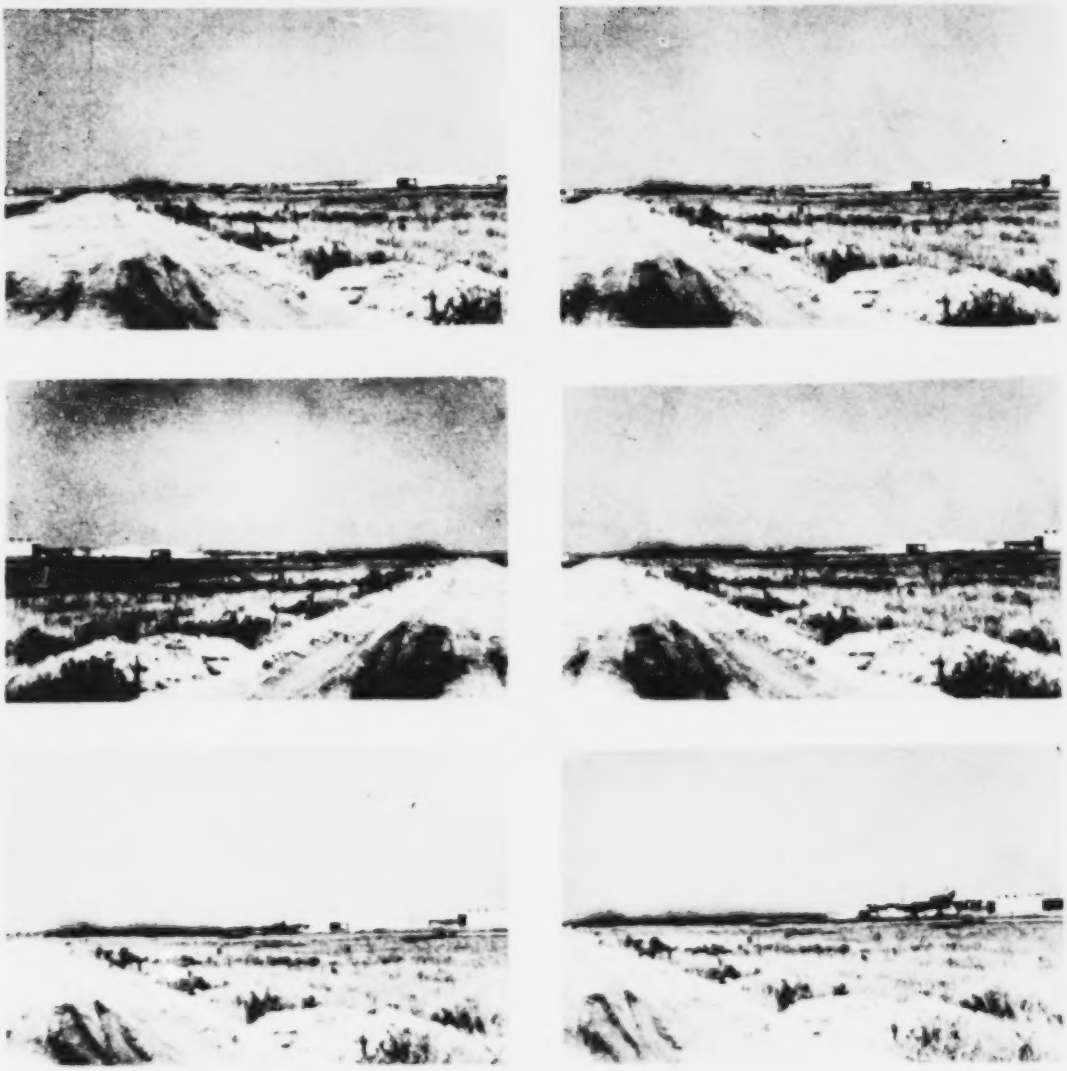

Figure 14. Takeoff and climbout sequence of a turbofan jet engine.

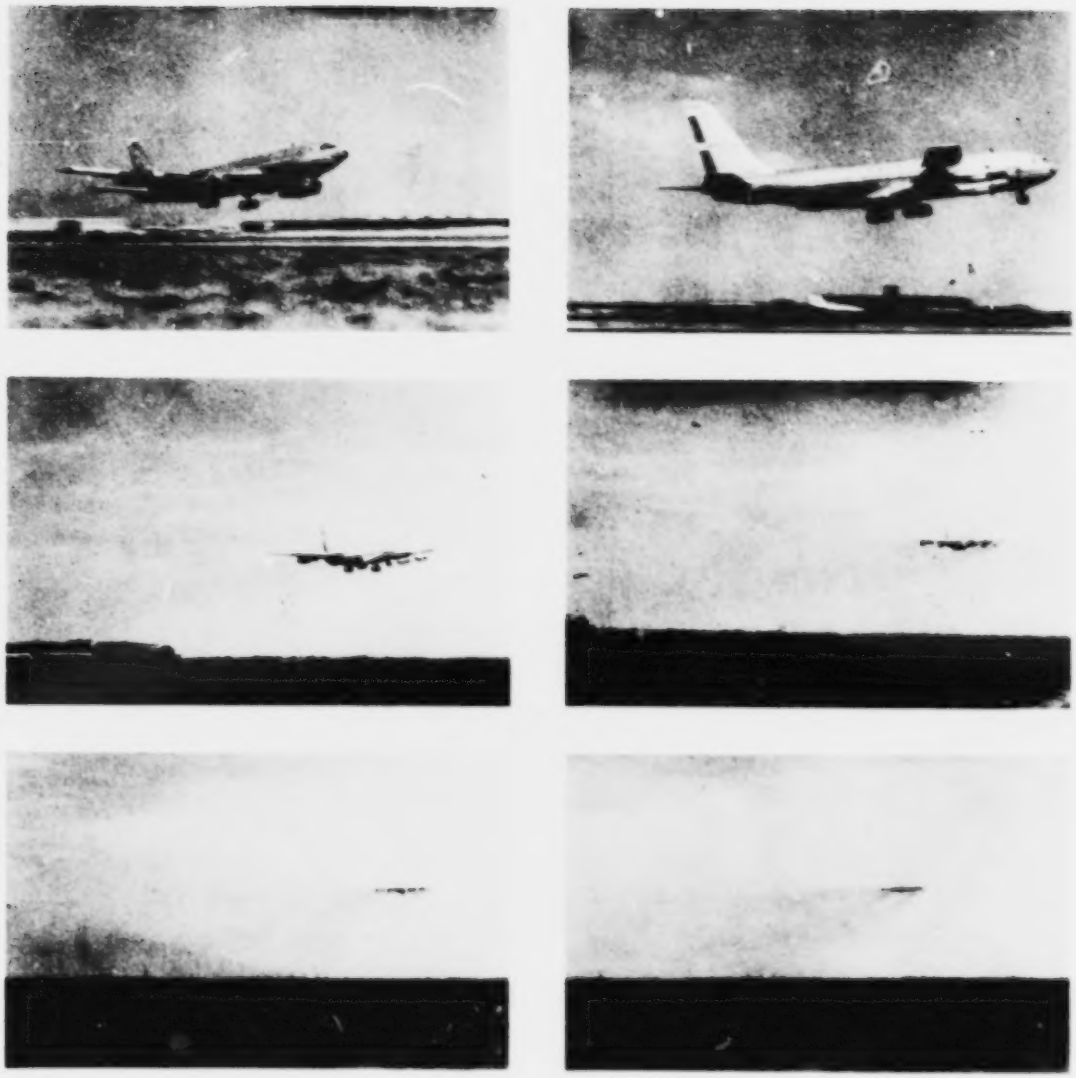

Figure 14 (continued). Takeoff and climbout sequence of a turbofan jet engine.

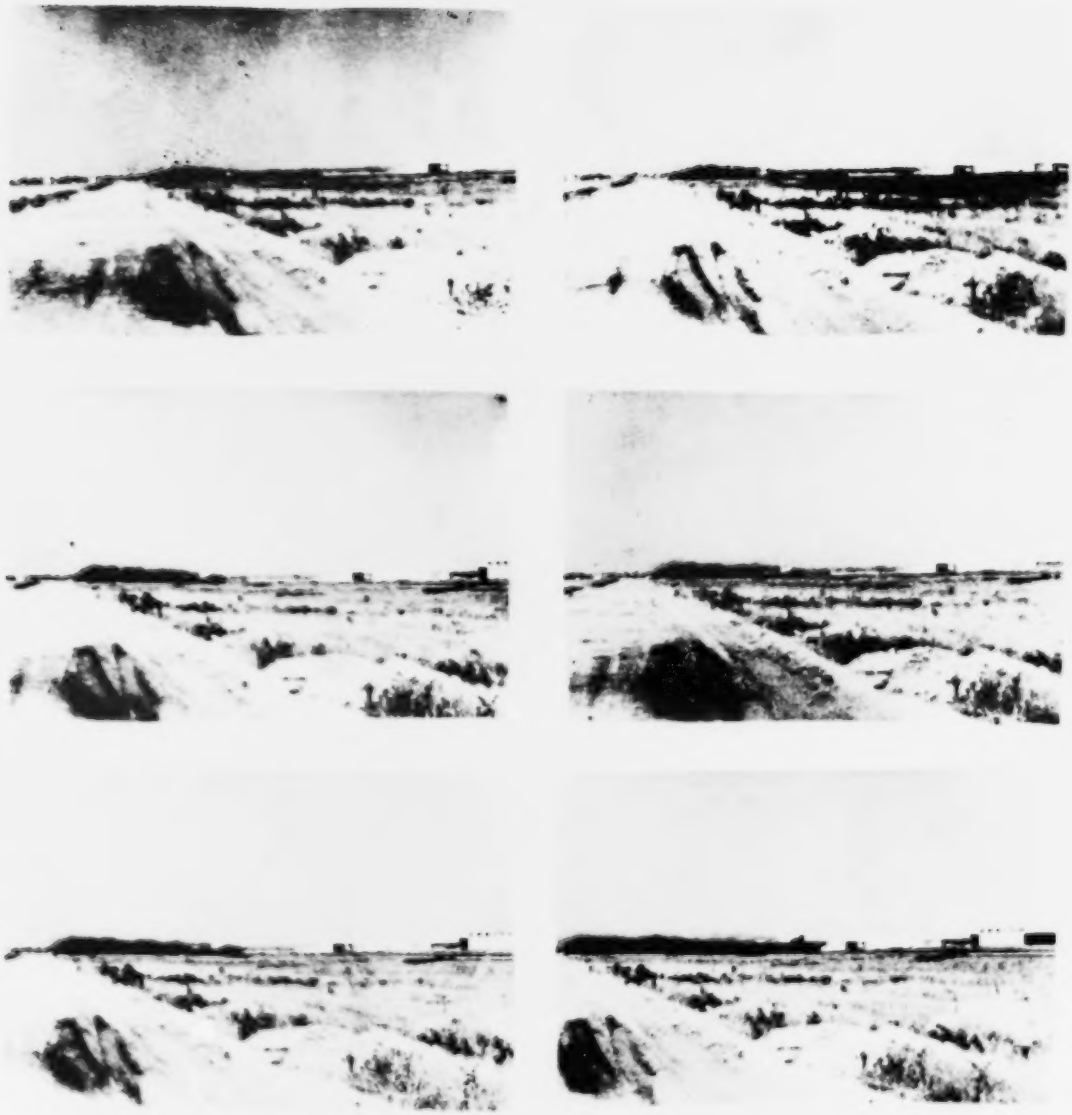

Figure 15. Takeoff and climbout sequence of a turbojet engine with water injection.

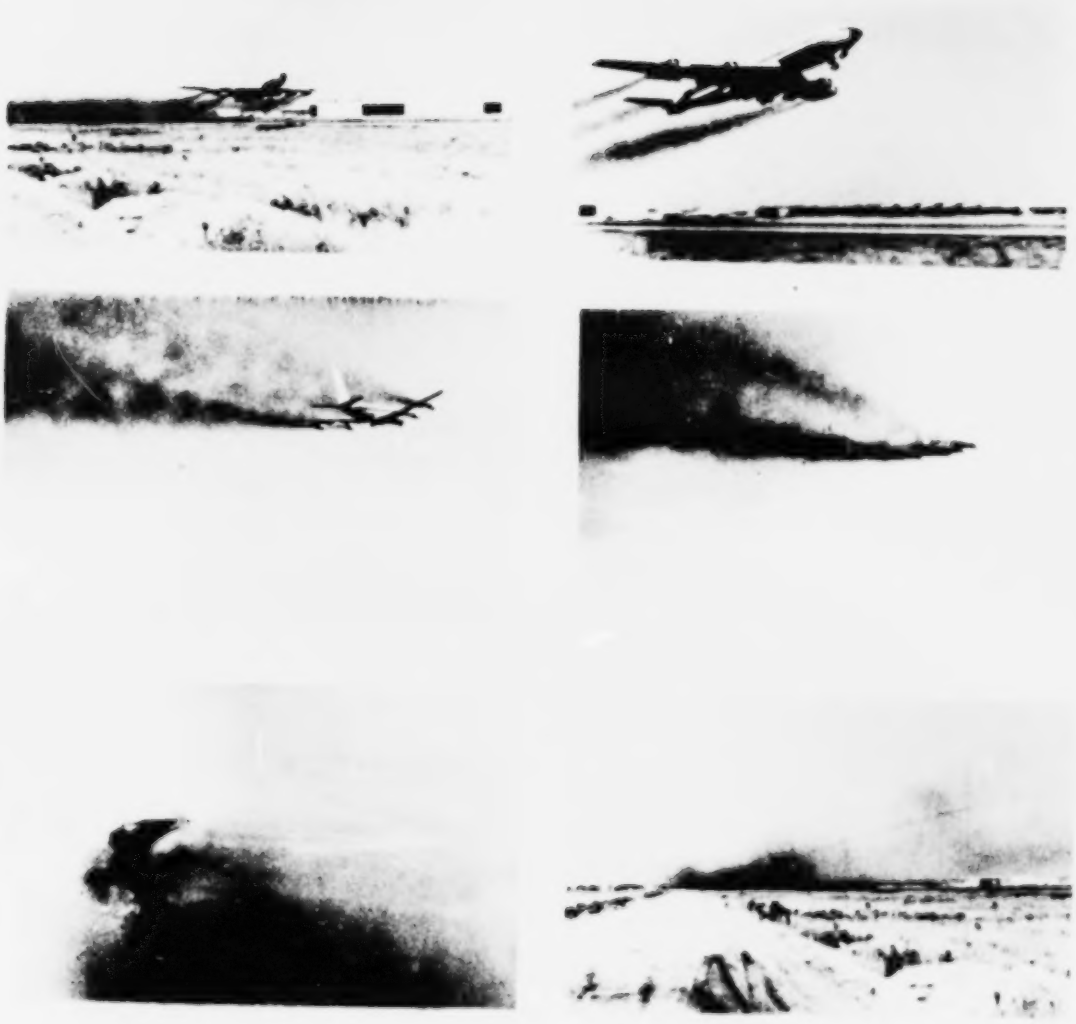

Figure 15 (continued). Takeoff and climbout sequence of a turbojet engine with water injection. (Final picture shows persistence of smoke cloud along runway.)

operations, as indicated above, the average hydrocarbon concentration measured during these hours when the wind direction was east to south-southwest (90^{o}-200^{o}) was compared to the average hydrocarbon concentration for all wind conditions during these same hours. The average and maximum hydrocarbon concentrations during 16 occurrences of wind directions of east to south-southwest were 3.8 ppm and 6.0 ppm, respectively. The average and maximum hydrocarbon concentrations for 124 observations during these same hours with all wind directions were 4.4 ppm and 13 ppm, respectively.

The average total hydrocarbon concentration at station 3 when winds were blowing from the airport east to south-southwest (90^{o}-200^{o}) and toward the sampling site indicated that airport and community pollution sources were equally responsible for hydrocarbon pollution at this site.

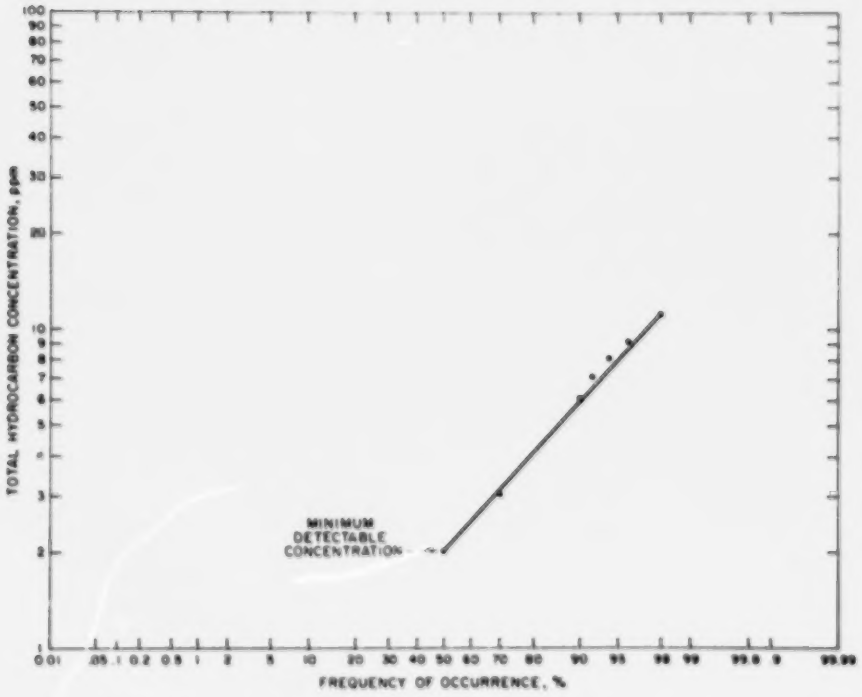

Figure 16. Cumulative frequency distribution of total hydrocarbon concentrations.

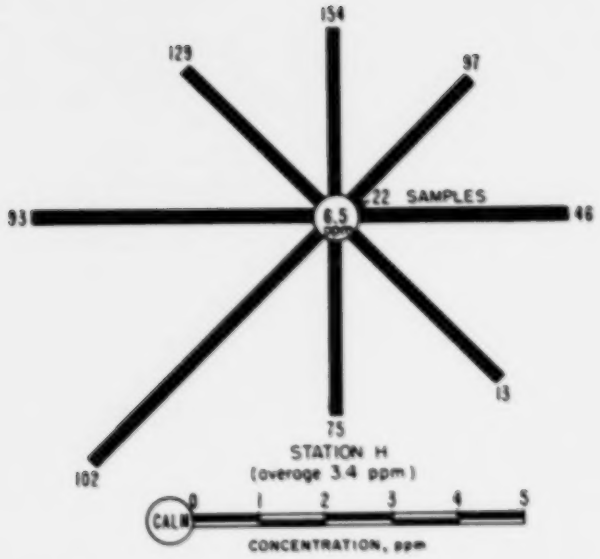

Figure 17. Variation of average hydrocarbon concentration with wind direction. (Numbers at end of direction radials refer to number of 1-hr samples.)

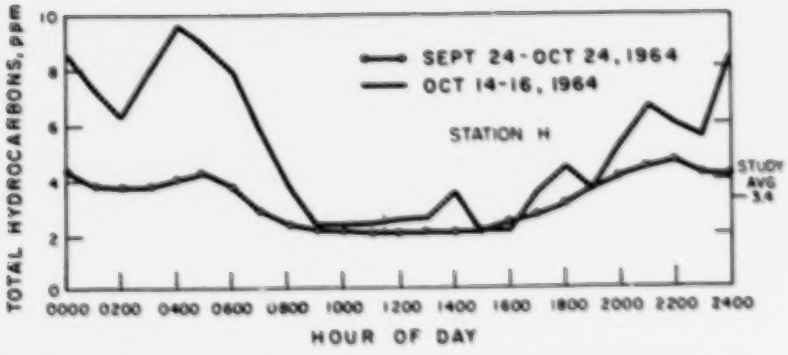

Figure 18. Average diurnal variation of total atmospheric hydrocarbons.

ODOR SURVEY

A survey was conducted for 10 days from October 3 through 9, and October 19 through 23, 1964, to determine the major types of odors in the area, particularly those that can be attributed to jet aircraft exhaust. An untrained odor-observer corps was used consisting of about 100 junior-high-school seventh and eighth grade science students that resided in the study area. Sensitivity tests were administered to the students by means of the "triangle" test using odorant solutions of vanillin, methyl salicylate, and butyric acid.[9] All students tested were found acceptable as observers. Students were instructed in the manner of making odor observations, and observations were made three times daily at 0700, 1600 and 2000 hours. Observers noted the strength of the odor, if observed, and described the odor in their own words on a data form provided (Appendix, Figure A1). The data subsequently were punched onto cards and analyzed by use of a card sorter.

The number, type, and location of odor observations are given in Table 5. The location and boundaries of each zone are shown in Figure 19. All communities surveyed are within 3 miles of the airport premises. The greatest percentage of positive odor responses occurred in the Rosedale area (Zone 3) followed by South Ozone Park (Zone 4). No odors were described by the students as jet exhaust smoke or odor. To determine whether odors described as gasoline and diesel engine exhaust, or oily or fuel odor could have possibly originated at the airport, these observations were compared with wind direction (Table 6).

Six of these observations were made at a time when odor originating at the airport could have been carried by wind to the observer, and 20 of these observations were made when odors from the airport were being carried away from the observer. These data indicate that gasoline and diesel exhaust, and oily or fuel odors cannot be specifically related to jet aircraft emissions, and that sources other than the airport are the main contributors.

For the 10 days of the survey, the prevailing wind direction during the hours of odor observations had a northerly component (Table 7), which would tend to disperse pollution originating at the airport away from the mainland. During one-third the hours of odor observations, however, meteorological conditions were conducive to transport of odors from the airport to the areas where odor observations were being made; this is indicated by the southerly component in wind direction. The relationship of odor response to hour of observation is shown in Table 8. The number of positive odor responses did not vary significantly with hour of observation.

Table 5. NUMBER, TYPE, AND LOCATION OF ODOR OBSERVATIONS

Type of odor	Total observations by zones			
	1	2	3	4
Total number of observations	238	260	335	198
Total number of positive observations	62	65	146	61
Percentage of positive observations[a]	26.1	25.0	43.6	30.8
1. Chemical odors (including chemical, sulfurous, soap or detergent, refinery, medicinal, vanilla or coumarin, bleach or chlorine, ammonia, other)	1	3	1	2
Percentage of positive observations[b]	1.6	4.6	0.68	3.3
2. Food processing odors (including coffee roasting, bakery, brewery, restaurant, grain, smoking fish, other, unknown)	1	1	1	1
Percentage of positive observations[b]	1.6	1.5	0.68	1.6
3. Combustion odors including the following:	10	36	46	22
Gasoline and diesel engine exhaust	0	0	11	5
Coke-oven and coal gas odors (steel mills)	2	0	0	6
Maladjusted heating systems	0	3	2	0
Coal smoke	6	0	1	0
Smokey	0	13	23	8
Other	2	4	0	3
Unknown	0	15	9	0
Jet exhaust smoke or odor	0	0	0	0
Percentage of positive observations[b]	16.1	55.4	31.5	36.1
4. General industrial odors (including asphalt, plastics, solvents, fertilizer plants, paint and related industries, oily, fuel odor, other, unknown)	11	2	0	8
Percentage of positive observations[b]	17.7	3.1	0	13.1
5. Animal odors (including rendering, stock yards, poultry, fish, organic fertilizer, meat processing plant, other, unknown)	0	1	3	7
Percentage of positive observations[b]	0	1.5	2.1	11.5
6. Odors from combustible waste (including open dump fires, city incinerators burning garbage, home incinerators, backyard trash fires and wood smoke, burning rubber, other, unknown)	14	5	14	6
Percentage of positive observations[b]	22.6	7.7	9.6	9.8
7. Decomposition odors (including sewage, non-burning garbage, other, unknown)	2	1	1	9
Percentage of positive observations[b]	3.2	1.5	0.68	14.8
8. Vegetation odors (including general, freshly cut wood, flowers and/or flowering shrubs, marshland odor, fresh fruit odors, plowed or excavated soil)	22	11	14	4
Percentage of positive observations[b]	35.5	16.9	9.6	6.6
9. Miscellaneous odors (including general, foul - not specified, putrid - source not specified, not pleasant, smog, clean or fresh, ocean smell, dust, tobacco)	1	5	66	2
Percentage of positive observations[b]	1.6	7.7	45.2	3.3

[a] $\frac{\text{Total number of positive observations}}{\text{Total number of observations}} \times 100$

[b] $\frac{\text{Number of odor types observed}}{\text{Total number of positive observations}} \times 100$

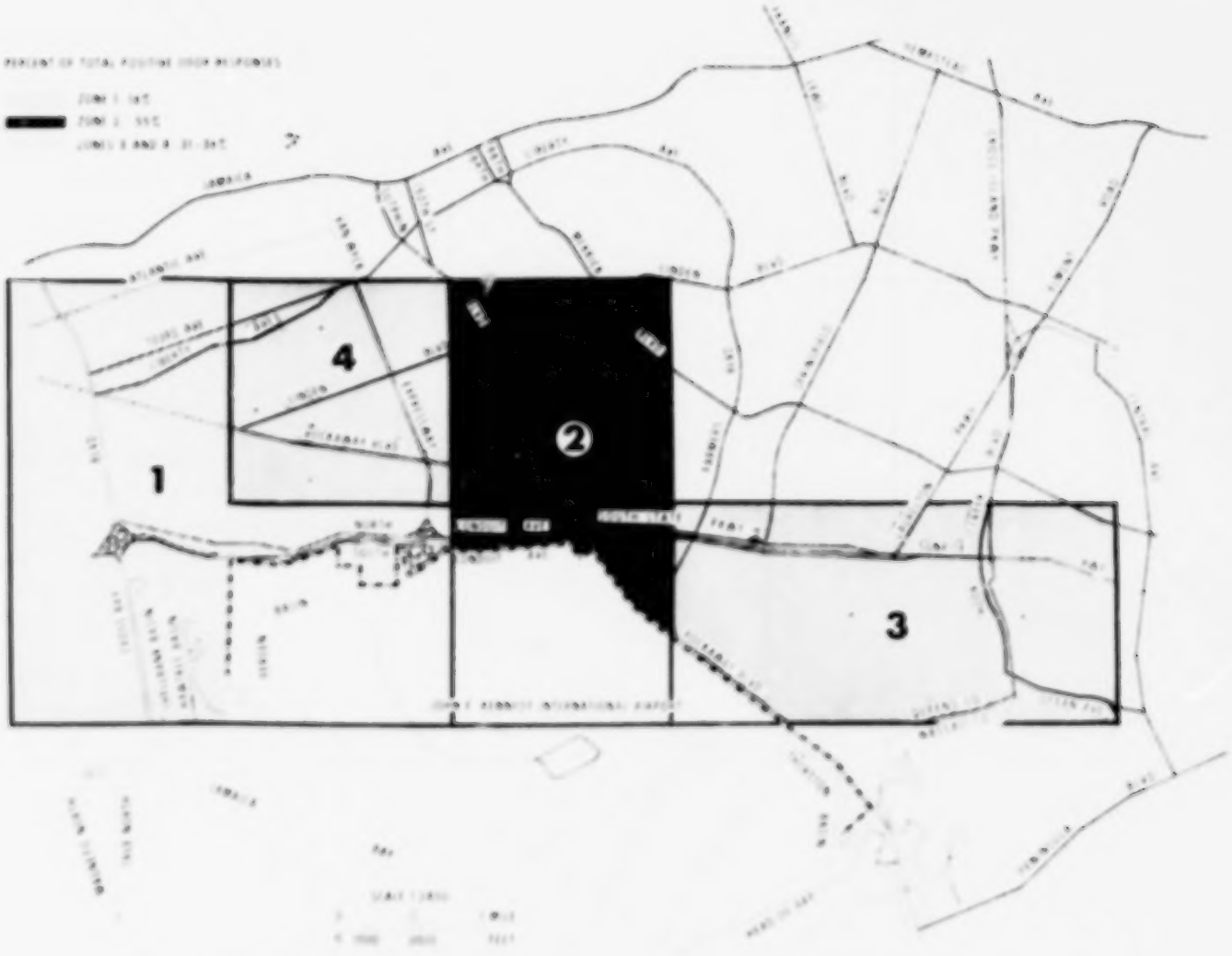

Figure 19. Distribution of combust on odors in the vicinity of John F. Kennedy Airport, October 5-9 and 19-23, 1964.

Table 6. COMPARISON OF CERTAIN COMBUSTION AND INDUSTRIAL ODORS AND WIND DIRECTION

Date, October 1964	Time	Zone	Wind direction	Wind speed, mph	Type of odor	Upwind (U) or downwind (D) of airport
5	0700	1	[illegible]	10	[illegible][a]	U
5	2000	1	[illegible]	4	[illegible]	U
5	1600	2	[illegible]	5	[illegible]	U
5	2000	2	[illegible]	4	[illegible]	U
6	0700	3	[illegible]	7	[illegible]	U
6	1600	1	[illegible]	6	Oily	D
7	1600	3	[illegible]	4	[illegible]	U
7	2000	3	[illegible]	7	[illegible]	U
7	0700	4	[illegible]	14	[illegible]	U
8	0700	1	[illegible]	11	Oily	U
8	1600	3	[illegible]	6	[illegible]	U
8	2000	3	[illegible]	6	[illegible]	U
8	0700	4	[illegible]	11	[illegible]	U
8	2000	4	[illegible]	6	Fuel	D
19	0700	4	[illegible]	2	[illegible]	U
19	0700	3	[illegible]	2	[illegible]	D
20	0700	4	[illegible]	5	[illegible]	U
21	0700	1	[illegible]	5	Oily	U
21	0700	4	[illegible]	5	Fuel	U
21	1600	3	[illegible]	11	[illegible]	D
22	0700	1	[illegible]	9	Oily	U
22	1600	1	[illegible]	10	Oily	U
22	1600	4	[illegible]	10	[illegible]	U
22	0700	3	[illegible]	5	[illegible]	D
23	0700	3	[illegible]	7	[illegible]	U

[a] Gasoline and diesel exhaust.

The results of the odor survey indicate that pollution due to odor from combustion and other sources is a problem; however, in no instance did the observer associate the emissions from jet aircraft with any of the odors observed. No jet exhaust odors were detected by members of the technical study staff while working and traveling in the communities around the airport during the period that air quality measurements were being made.

The possibility that emissions from jet aircraft do create an odor problem should not, however, be discounted. Odors from this source may be apparent during other seasons of the year or during more adverse meteorological conditions. Further investigations should be considered.

Table 7. METEOROLOGICAL CONDITIONS AT STATION H DURING ODOR SURVEY

Date, Oct 1964	Hour of observation		
	0700	1600	2000
	Wind direction and speed, mph	Wind direction and speed, mph	Wind direction and speed, mph
5	N,10	N,5	NNE,4
6	N, 7	S,6	C
7	NNE,14	N,4	N,7
8	NNE,11	SSE,6	SE,6
9	C	S,12	S,9
19	W,2	NW,12	NW,9
20	NW,5	NNE,8	NNE,7
21	NW,5	SSW,11	SW,20
22	SSW,5	NW,9	NW,10
23	NNW,7	NW,15	NNW,11

Table 8. POSITIVE ODOR RESPONSES BY HOUR OF OBSERVATION

Observations	Hour		
	0700	1600	2000
Total observations	426	422	420
Positive observations	109	111	95
Percentage positive observations	25.6	26.3	22.6

DAYS OF HIGH AIR POLLUTION

Diurnal variations of soiling index values, wind speed, and total atmospheric hydrocarbons from October 14 through 16 are compared to the average diurnal variations for the study period (Figures 2 and 18). From October 14 through 16, the highest 2-hour soiling index values were about twice as great as the highest 2-hour values for the study as a whole (Figure 2); the highest hourly hydrocarbon concentrations were also about twice as great (Figure 18). Average concentrations were not significantly greater than the study average, which indicates there were

only a few hours of accumulation of pollution. Wind speeds were generally lower; the average wind speed was 6.8 mph compared to a study average of 9.8. The average suspended particulate concentration of all samples collected during the study period was 96 $\mu g/m^3$; the October 14 through 16 average concentration was 173. The prevailing wind direction during the latter period was southwest compared to a prevailing wind direction of north for the study period. Pollution roses for soiling index and hydrocarbon concentration (Figures 20 and 21) were similar to

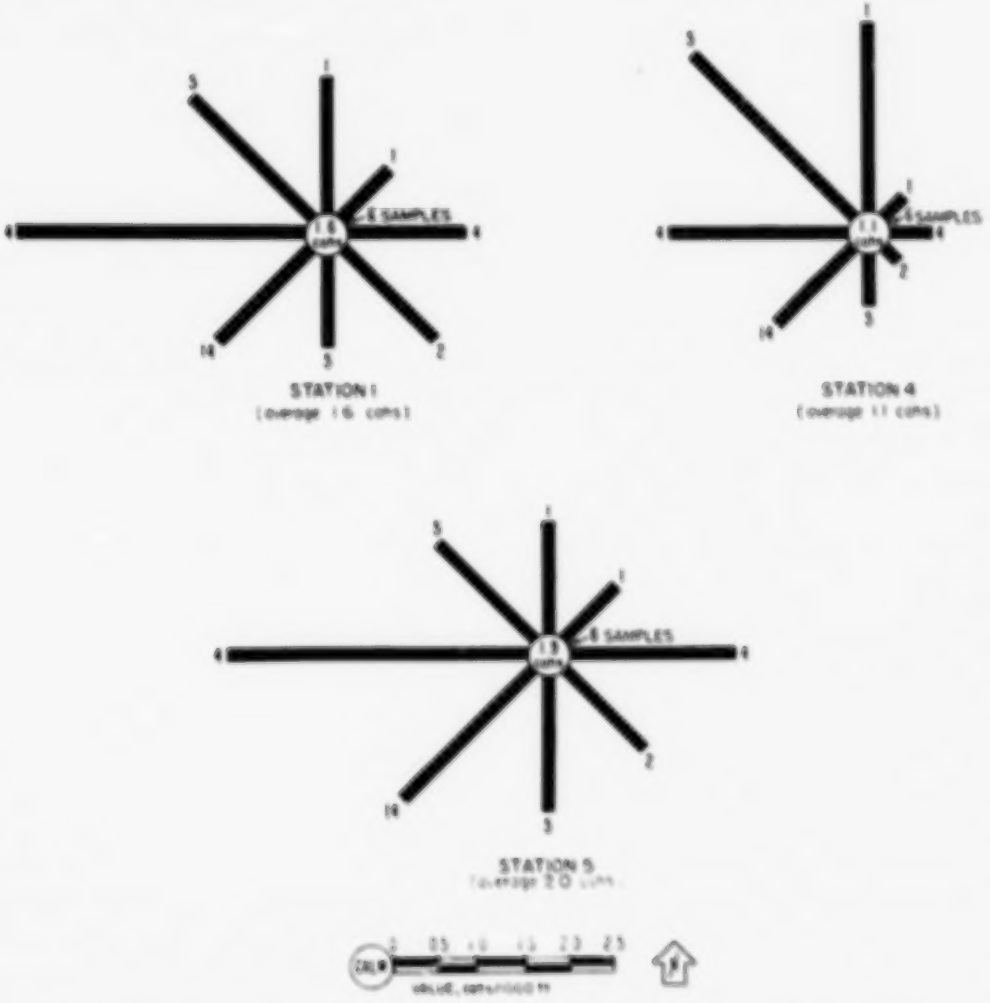

Figure 20. Variation in soiling index values with wind direction for October 14-16, inclusive. (Numbers at end of direction radials refer to number of 2-hr samples.)

those obtained for the entire study (Figures 6 and 17) except that for October 14 through 16 a higher soiling index was measured at each wind direction, and greater-than-average hydrocarbon concentrations were measured at all wind directions except north. The relatively high suspended particulate concentrations measured during adverse meteorological conditions indicate that particulate emissions are excessive in the areas of the sampling sites.

METEOROLOGICAL CONSIDERATIONS

The nearby ocean has considerable and varying effects on the New York metropolitan area, which are manifested in heating requirements (degree-days), wind speed, and prevailing wind direction. A degree-day is a measure of the departure of the mean daily temperature from 65°F. For example, if the average daily temperature for a given day is 50°F, the number of degree-days for this day is 65°F-50°F, or 15. In Table 9, meteorological data for John F. Kennedy International Airport are compared with data for Newark Airport in New Jersey, La Guardia Field, and Central Park in New York City. Heating requirements are greatest at J. F. Kennedy International Airport and least at La Guardia Field. Wind speed is consistently highest at La Guardia Field, while Central Park, surrounded by buildings

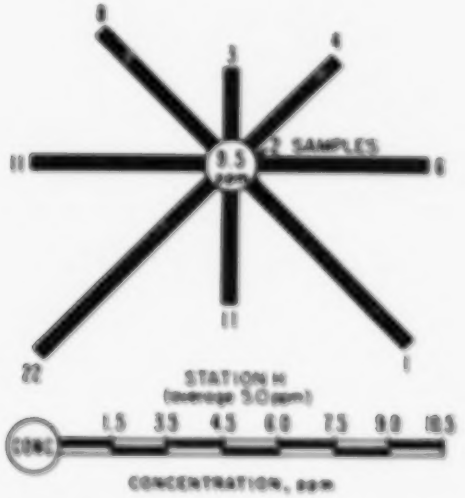

Figure 21. Variation of average hydrocarbon concentration with wind direction, October 14-16, inclusive. (Numbers at end of direction radials refer to number of 1-hr samples.)

Table 9. COMPARATIVE MONTHLY AVERAGE METEOROLOGICAL CONDITIONS

Meteorological parameter	Location	Length of record, yr	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Degree days	(1)	30	1029	935	815	480	167	12	0	0	36	248	564	933
	(2)	30	973	879	750	414	124	6	0	0	27	223	528	887
	(3)	30	986	885	760	408	118	9	0	0	30	233	540	902
	(4)	30	1014	904	760	411	127	9	0	0	39	276	588	939
Precipitation, inches	(1)	30	3.23	2.93	4.15	3.48	3.67	3.35	4.04	4.97	4.16	3.21	3.51	3.23
	(2)	30	3.31	3.09	4.23	3.57	3.58	3.38	3.71	5.08	3.92	3.37	3.59	3.59
	(3)	30	3.31	2.84	4.01	3.43	3.67	3.31	3.70	4.44	3.87	3.14	3.39	3.26
	(4)	30	3.33	2.80	4.09	3.51	3.65	3.44	3.67	4.43	3.76	3.11	3.37	3.22
Snowfall, inches	(1)	6	7.3	8.8	5.6	T	0	0	0	0	0	0.1	0.1	7.6
	(2)	19	6.6	8.5	5.9	1.0	T	0	0	0	0	0.1	0.6	8.0
	(3)	95	7.6	8.5	5.4	1.0	T	0	0	0	0	T	1.0	6.2
	(4)	22	6.8	7.4	5.6	0.7	T	0	0	0	0	T	0.5	8.7
Wind speed, mph	(1)	6	13.4	14.1	13.9	13.3	11.6	11.0	10.9	10.3	11.1	11.1	12.2	12.4
	(2)	15	14.7	14.6	15.3	13.7	11.9	11.0	10.5	10.4	11.3	12.3	13.3	14.3
	(3)	44	11.1	11.1	11.3	10.8	9.0	8.3	7.8	7.8	8.3	9.2	10.2	10.5
	(4)	20	11.1	11.4	12.1	11.3	9.9	9.2	8.7	8.4	8.8	9.3	10.1	10.6
Prevailing wind direction	(1)		Record too short at present site											
	(2)	14	WNW	WNW	NW	NW	NE	S	S	S	S	SW	WNW	WNW
	(3)	44	NW	NW	NW	NW	SW	SW	SW	SW	SW	SW	NW	NW
	(4)	22	NE	NW	NW	WNW	SW	SW	SW	SW	SW	SW	SW	SW
Sky cover, daylight hours, tenths	(1)	6	6.1	6.5	5.9	6.3	6.0	6.1	6.1	6.0	5.2	5.1	6.0	5.9
	(2)	15	6.6	6.5	6.2	6.4	6.4	5.9	5.9	5.9	5.6	5.3	6.2	6.3
	(3)	39	6.1	5.8	5.8	5.9	5.8	5.7	5.5	5.5	5.2	5.6	5.8	5.9
	(4)	18	6.5	6.4	6.1	6.5	6.5	6.0	6.1	6.0	5.5	5.3	6.1	6.1
Heavy fog, No. of days	(1)	6	3	4	4	3	3	4	3	2	2	2	2	3
	(2)	15	3	1	1	2	2	2	1	1	< 1	1	1	1
	(3)		Not recorded											
	(4)	22	3	2	2	2	2	2	1	1	1	3	2	2

(1) John F. Kennedy International Airport, New York, N.Y.
(2) LaGuardia Field, New York, N.Y.
(3) Central Park, New York, N.Y.
(4) Newark Airport, Newark, N.J.

of many sizes and shapes, shows the lowest. The record at J. F. Kennedy International Airport for the present exposure of instruments was too short to establish a prevailing wind direction. At the three other locations, prevailing wind directions changed with the seasons and only in March and October did they agree; disagreement ranged from 45° to as high as 180°.

Wind Direction

When an attempt is made to relate ambient pollution levels to specific sources, wind direction data are of the utmost importance; however, because of the channeling effects of streets and tall buildings in metropolitan areas, wind direction at street level is perhaps the most difficult factor to evaluate. Prevailing directions obtained by measurement in a nearby well-exposed location give an indication of general air movement over the area, but even within a few miles marked differences occur (Table 9). Wind roses (Figures 22 and 23) representing average seasonal data at John F. Kennedy Airport over a 5-year period, 1954-1958, for 0300 EST and 1500 EST illustrate the seasonal and diurnal variation in wind direction. The wind roses for the fall season (September, October, November) show a definite sea-breeze effect, though less pronounced than during summer. Winds from the east-southeast, southeast, and south-southeast are about five times as frequent in the afternoon as during the early morning, while winds from the north, north-northeast, and northeast are two to three times as frequent in the early morning as during the afternoon. Other directions show less diurnal variation in frequency and are more likely the result of movement of large scale meteorological systems through the area. The hours of 0300 and 1500 were selected to show the maximum diurnal change in wind direction. Wind roses for two 3-hour periods during the study period (Figures 24 and 25) were compared with the average wind rose for the fall season (Figure 26).

The method of reporting wind direction was changed January 1, 1964, from 16 compass directions to tens of degrees in azimuth. In adjusting the study data to a 16-point rose some bias is introduced favoring the cardinal directions (north , east, south, west). In addition, each wind rose for the study period (Figures 24 and 25) includes data for a 3-hour period instead of the single hour used in the average wind roses. With these points in mind, it is apparent that northerly winds were much in excess of average frequency for both times of day, and the total absence of winds from the east-southeast through south in the early morning is quite noticeable. In the afternoon, south winds were in excess of average frequency, although if the southerly directions (south-southeast, south, and south-southwest) are considered as a group a deficiency in frequency is again noted. Northwest

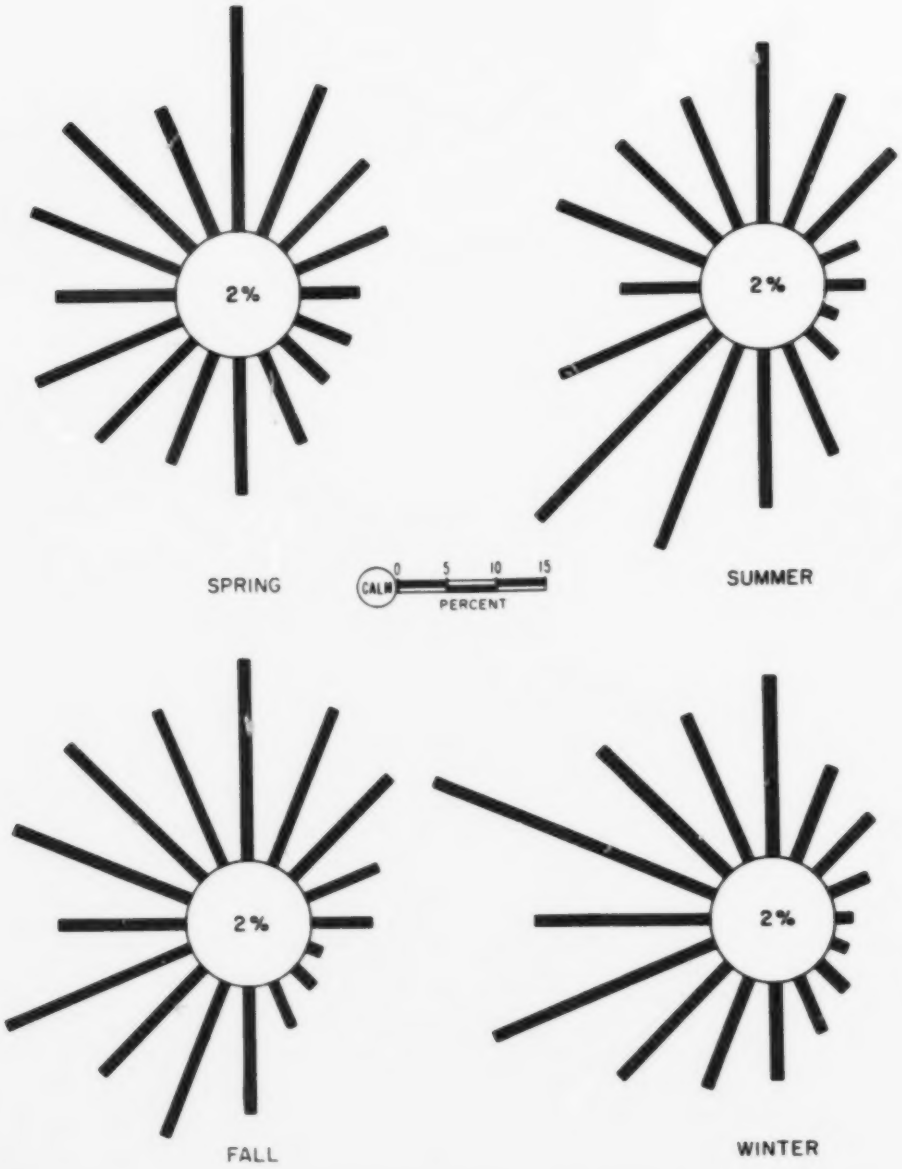

Figure 22. Seasonal wind direction frequency distribution for 5 years, 1954-1958, at 0300 hours at John F. Kennedy Airport.

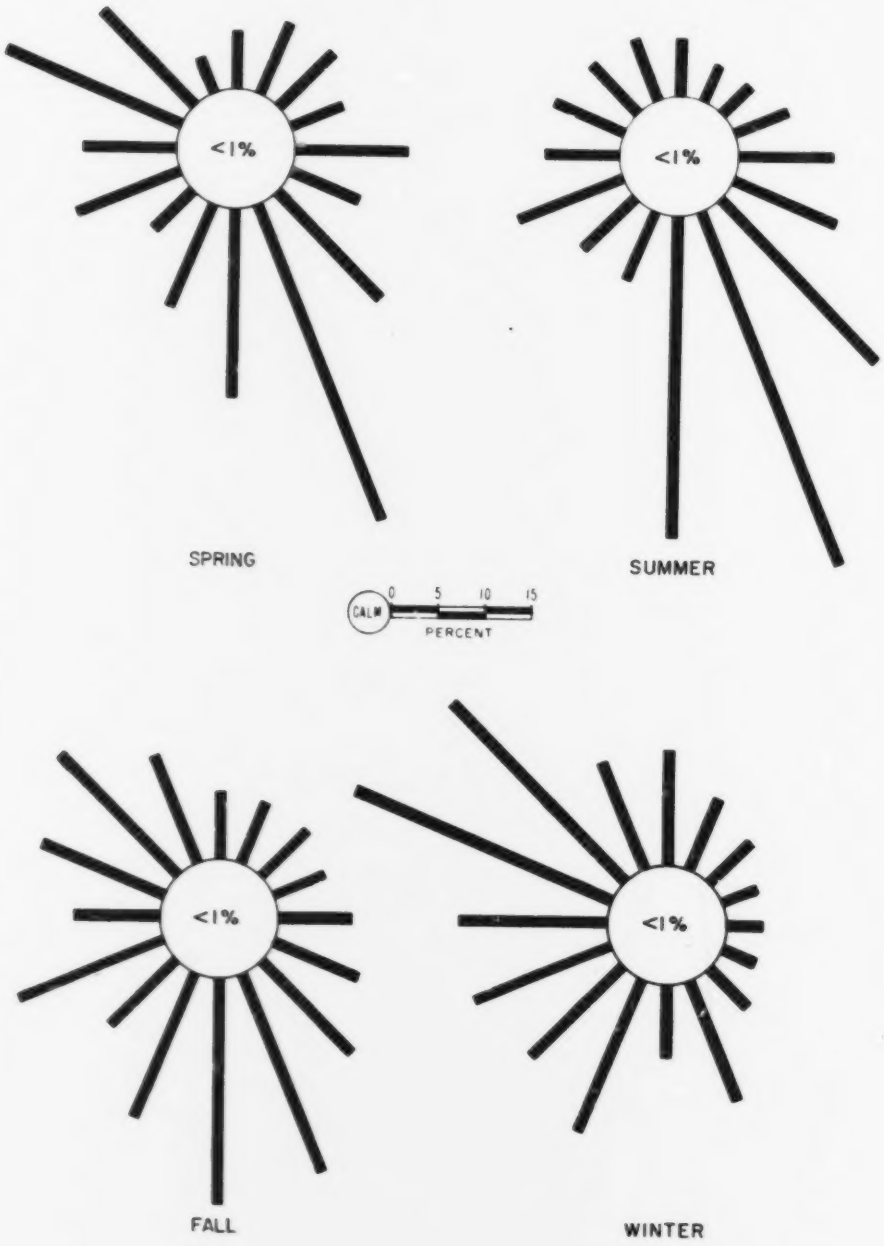

Figure 23. Seasonal wind direction frequency distribution for 5 years, 1954-1958, at 1500 hours at John F. Kennedy Airport.

winds in the afternoon were much in excess of average frequency, and without benefit of any bias in adjusting data.

At the sampling sites to the northwest and north of the John F. Kennedy International Airport (stations 4, 5, and H) it is evident that fewer than normal samples were obtained of air moving across the airport (none at all during early morning hours), and that a greater-than-normal number of samples were obtained of air moving across the city. At the site southeast of the airport (stations 1, 2, and 6), a near normal number of samples were obtained of air moving across the airport at all hours, and an excessive number of samples of air moving from the north near the eastern boundary of the airport. For all sites, the dearth of southeasterly winds creates a gap in the sampling data.

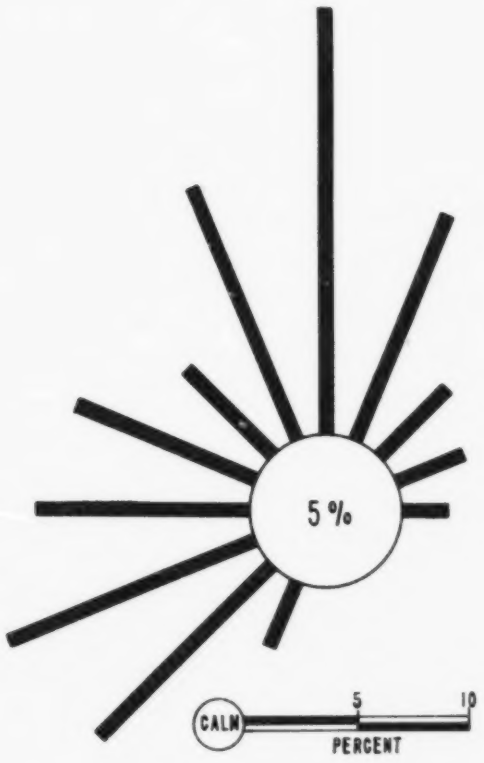

Figure 24. Wind direction frequency distribution, September 24 to October 24, inclusive, from 0100 to 0400 hours at John F. Kennedy Airport.

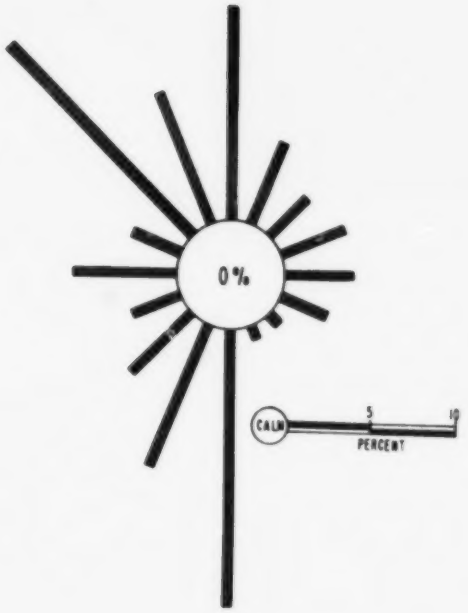

Figure 25. Wind direction frequency distribution, September 24 to October 24, inclusive, from 1300 to 1600 hours at John F. Kennedy Airport.

Stability

Hosler[10] showed a low-level inversion frequency of 24 percent at 1900 EST and 30 percent at 0700 EST during the fall season, with such low-level inversions present 26 percent of the time during that season. Radiosonde observations during this study showed such inversion present 16 percent of the time at 1900 EST and 28 percent of the time at 0700 EST. This indicates a significant variation from normal conditions for the evening hours, with fewer inversions and consequently better dispersion conditions than normal, when this factor is considered alone.

Wind Speed

In urban areas where there are many sources of pollution, generally the lower the wind speed the greater the concentration of pollution. In most cities this effect is most pronounced at low wind speed (7 mph or less). High winds are not

always beneficial, however, since local incidence of high pollution can occur from aerodynamic downwash of stack effluents with high winds. High winds can also pick up particulates from streets and bare ground, such as wide expanses of airports or areas cleared for new construction or in the process of urban renewal, as well as from cultivated fields in rural areas.

Figure 26. Average wind rose for fall season at John F. Kennedy Airport.

Average wind speed for the sampling period September 24 through October 24, 1964, at John F. Kennedy Airport was 9.8 mph. The 6-year average for this Airport for both September and October is 11.1 mph. The average speed observed was thus slightly less than normal. Calm occurred 22 hours, or 3 percent of the time. There were 4 days with 12 or more hours of wind less than 7 mph, 1 of them with 17 hours (October 14), and on October 13-14 there were 14 consecutive hours of wind less than 7 mph (Table 10).

Table 10. WIND SPEED DATA FOR J. F. KENNEDY AIRPORT, SEPT. 24 - OCT. 24, 1964

	Sept.		Oct.									
Date	26	30	2	6	7	8	9	12	13	14	16	20
Avg. speed, mph	9.0	6.9	6.0	4.4	10.1	6.8	6.4	7.1	6.3	5.8	7.0	7.0
Hours less than 7 mph	11	10	12	16	6	8	11	8	13	17	11	10
Hours of calm	1	1	1	3	1	0	5	4	3	2	1	0

Stagnation

Extended periods of low wind speeds, usually associated with high stability, have been studied by Korshover.[14] He found that in a 21-year period, 1936-1956, the New York City area experienced about 12 periods of stagnation lasting 4 or more days during the months of September and October, which would give an expected frequency of three in 10 years for the 31-day period of the study. Such stagnant periods are favorable for the accumulation of air pollution, and forecasts are made by the Weather Bureau Research Station at the Robert A. Taft Sanitary Engineering Center of the U. S. Public Health Service, Cincinnati, Ohio, when poor dispersion conditions are expected to persist over a fairly large area for at least 36 hours. These forecasts are referred to as "high air pollution potential advisories" and are transmitted to local U. S. Weather Bureau offices by teletype. There were no such advisories issued for the New York City area during the study period. Since such advisories are issued only when a large area is affected, their lack does not discount the local occurrence of conditions favorable to accumulation of air pollution. Examination of surface and radiosonde observation data from the John F. Kennedy International Airport indicated that a poor dispersion condition did occur during the study period, on October 12th through the 16th. On October 12th, 0700 EST, radiosonde observation showed a surface-based inversion to be present. This surface-based inversion appeared in every radiosonde observation through 0700 EST on the 17th except at 1900 EST on the 13th and 0700 EST on the 14th when it was replaced by a stable layer at the surface in one case and an inversion based at around 3000 feet in the other. Low wind speeds and persistent smoke characterized this period.

Temperature

The principal effect of temperature on air pollution is in regard to space heating. Heating requirements are measured in degree-days by heating engineers. Normal monthly degree-days are shown in Table 9. The daily variation in heating

requirements at John F. Kennedy Airport during this study is presented in Figure 27. The study period was one of rapidly changing heating requirements; an excess of 103 degree-days occurred, about 72 percent above normal for this period.

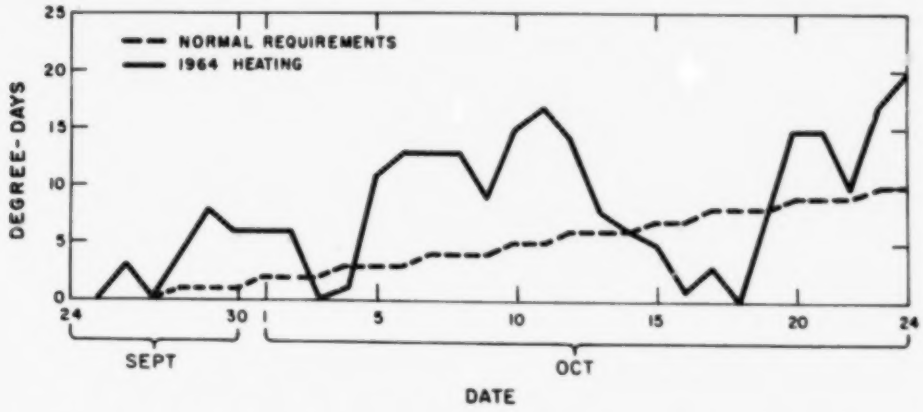

Figure 27. Comparison of normal daily heating requirements and those during the study period at John F. Kennedy Airport.

Precipitation

Precipitation is of interest because it partially washes out or, in the case of snow, partially scours out pollution. It also reduces dust when the ground becomes wet or snow covered.

A total of 3.63 inches of precipitation was measured at John F. Kennedy International Airport during the sampling period. This was slightly above normal for the period. In Central Park, precipitation was 2.90 inches or about 0.65 inches less than normal.

Table 11. DATES AND AMOUNTS OF PRECIPITATION OF 0.01 INCH OR MORE AT J. F. KENNEDY AIRPORT, SEPT. 24 - OCT. 24, 1964

	September			October					
Date	28	29	30	2	3	17	18	20	21
Amount, in.	0.15	1.37	0.08	0.59	0.29	0.52	0.12	0.40	0.11

There were 9 days with measurable rainfall (0.01 inch or more) at both Central Park and John F. Kennedy International Airport (Table 11) during the 31-day period of the study. This agrees with the normal expectancy of 9 days each in September and October.

Little or no snowfall was expected during the study period, and none was recorded.

Sunshine

Sunshine is a factor in photochemical-smog production; atmospheric mixing may be increased when the ground is sufficiently heated by solar radiation to cause convective currents.

The solar radiation measurements nearest to John F. Kennedy International Airport are made at Central Park, New York. Normally the Central Park station measures 63 percent of possible sunshine in September and 61 percent in October. Daytime cloudiness provides a means of comparing sunshine duration, and such data are available for both Central Park and John F. Kennedy International Airport. In Central Park daytime cloudiness averages 52 percent of sky coverage in September, and 51 percent in October. At John F. Kennedy International Airport the corresponding figures are the same, indicating a similar lower percent of possible sunshine. The daytime cloud cover recorded at the airport during the study period averaged 54 percent, indicating that conditions were nearly normal and that sunshine duration was about normal or slightly below.

Visibility

On October 13, 15, and 16, visibility at the John F. Kennedy Airport was reduced to 4 miles or less. A relative humidity of 56 percent or less indicated that fog was not a factor. Fog was not recorded for any hours included in Table 12, although in some cases high relative humidity may have contributed to the visibility reduction due to condensation on smoke or haze particles. In the Long Island area, as in most urban areas, restrictions to visibility with relative humidities of less than 70 percent would be attributed to air pollution.

Table 12. OCCURRENCE OF REDUCTION IN VISIBILITY BY SMOKE, OR SMOKE AND HAZE FOR MORE THAN 3 HOURS AT J. F. KENNEDY AIRPORT, SEPT. 24 - OCT. 24, 1964

Date	September 30	October 12	13	14	15	16	19
Duration, No. of hr.	4	5	14	6	12	11	11

An examination of the particular hours when visibility was reduced by smoke showed that the wind speed was almost invariably less than 10 miles per hour.

Conclusion

No outstanding or unexpected meteorological conditions apparently occurred during the sampling period (Appendix, Tables A-7 through A-10). The factors that would have significantly affected air pollution concentrations were sufficiently near normal to indicate approximately average conditions. The two most important

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factors in dispersion, stability and wind speed, appear to have offset each other with fewer-than-normal inversions and less-than-normal wind speed.

Atmospheric stagnation leading to buildup of higher pollution concentrations are expected in the fall months. The period October 12 through 16, when visibility was frequently reduced by smoke, is an example of such buildup. With this possible exception, results for the sampling period cannot be used to infer concentrations of air pollution that might occur under more adverse meteorological conditions.

AIRCRAFT OPERATIONS

A summary of aircraft operations at major airports in the United States in 1962 and 1963 relative to total operations, percentage of jet aircraft operations, and use of water injection during takeoff is shown in Table 13. In 1964, the percentage of jet aircraft operations of the total operations at John F. Kennedy Airport increased to about 64 percent (184,000 jet operations out of 289,000 total commercial operations) and the percentage of water-assisted jet departures of the total jet departures decreased to about 8 percent. This downward trend in the percentage of water-injection jet aircraft operations to total jet traffic is expected to continue because of the addition of fanjet-powered aircraft to commercial jet fleets. In 1964, the total number of jet departures was about 93,000, of which about 7,400 were water assisted.[4] In 1963, Chicago's O'Hare Airport was the busiest and John F. Kennedy Airport had the greatest amount of jet traffic.

The most frequently used runways at J. F. Kennedy Airport are the east - west runways (31L and 31R) (Table 14 and Figure 1). These runways are used unless the wind speed is greater than 17 miles per hour with a wind direction of north or south. North - south runways are used in this case (runways 4R and 4L). Generally, takeoffs are performed on runway 31L from east to west and upon reaching 500 feet altitude the aircraft executes a 90-degree turn to the south and proceeds over Jamaica Bay. Takeoffs are therefore carried out mainly over the least populated areas, primarily because of the noise levels associated with jet aircraft operations.

Hourly variation in the total number of flights is shown in Figure 5. These data were obtained on 7 consecutive days from September 24 to September 30, 1964. Greatest number of flights occurred from 1400 to 2300. Hourly diurnal variation in jet departures and arrivals for 7 consecutive days between September 24 to October 30, 1964, inclusive, are shown in Figures 3 and 4. The greatest numbers of jet departures occur from 0800 to 1100 and from 1500 to 2300. The greatest numbers of arrivals occur from 1400 to 2300.

Table 13 YEARLY AIRCRAFT OPERATIONS AT MAJOR AIRPORTS IN CONTINENTAL UNITED STATES IN 1962 and 1963[a]

	Total operations (departures and arrivals)		Total jet operations (departures and arrivals)		Total jet departures		Jet departures (water injection)		Total prop operations		Percent water injection, jet departures[b]		Percent jet aircraft operations[c]	
	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963
Atlanta	143,586	160,750	18,586	31,655	9,376	15,828	2,407	1,281	126,834	129,078	25.67	8.09	13.1	19.7
Baltimore	72,108	52,392	23,960	13,340	11,980	6,670	3,866	1,886	48,148	38,982	32.27	28.27	33.2	25.5
Boston	108,056	85,908	16,392	21,382	8,196	10,691	1,129	2,275	91,664	64,526	13.77	17.64	15.2	24.9
Chicago	291,952	330,080	112,960	120,048	56,480	60,024	18,803	18,477	178,992	209,972	33.29	30.78	38.7	36.4
Detroit	91,504	103,362	18,642	22,180	9,321	11,090	4,066	3,152	72,862	81,182	43.83	28.42	20.4	21.5
Houston	53,956	60,386	19,002	33,980	9,501	16,990	576	24	32,564	26,406	6.0	0.1	35.0	56.0
Los Angeles	133,969	151,726	85,612	94,994	42,806	47,497	17,581	19,014	48,064	60,732	41.07	40.03	64.0	61.0
New York, JFK	297,085	314,489	106,766	163,394	53,383	81,697	6,621	9,504	190,319	251,095	12.0	11.6	36.0	52.0
Philadelphia	99,80.	109,704	15,422	20,960	7,711	10,480	2,326	2,718	84,378	88,744	30.16	25.93	15.5	19.1
Pittsburgh	88,524	93,252	11,488	16,972	5,744	8,486	1,810	2,455	77,036	76,280	31.51	28.93	13.0	18.2
St. Louis	81,958	77,586	14,268	18,616	7,134	9,308	4,352	6,503	67,690	53,970	61.00	69.86	17.4	25.6
San Francisco	106,058	114,292	49,940	58,576	24,970	29,288	9,482	8,628	56,118	55,716	37.97	29.45	47.1	51.3

[a] Airport activity statistics of certificated route air carriers, Federal Aviation Agency and Civil Aeronautics Board.

[b] $\frac{\text{Jet (water injection) departures}}{\text{Total jet departures}} \times 100$

[c] $\frac{\text{Total jet operations}}{\text{Total aircraft operations}} \times 100$

Table 14. ANALYSIS OF RUNWAY UTILIZATION AT JOHN F. KENNEDY AIRPORT

Year	Operations	Total operations all runways	Most frequently used runways	Percentage utilization
1961	Takeoffs	135,400	31 L	49.2
	Landings	135,768	4 R	26.0
1962	Takeoffs	148,101	31 L	46.6
	Landings	148,300	4 R	28.1
1963	Takeoffs	157,340	31 L	47.2
	Landings	157,149	4 R	23.6
1964 (Jan-July)	Takeoffs	97,144	31 L	48.7
	Landings	97,536	31 R	25.8

COMPLAINT RECORDS AND OPINIONS FROM NEW YORK CITY AND OTHER COMMUNITIES

A request for information about the magnitude of the air pollution problem that could be attributed to jet aircraft operations was directed to air pollution control officers in 11 major cities in the continental United States. A summary of complaint records from those that reported and a description of land use in the vicinity of the airports are summarized in Table 15. These records indicate that the pollution problem due to aircraft operations is nominal. All air pollution authorities that reported agreed that the smoke trails produced by jet aircraft were aesthetically objectionable.

Since April 1962, all public complaints attributed to aircraft operations received by the New York City Department of Air Pollution Control have been referred to the Air Pollution Program Director, Region II, Public Health Service. Local authorities in New York believe that regulation of emissions from aircraft is a responsibility of the Federal Government and that they have no jurisdiction in the matter. A relatively small number of complaints are on record (Table 16).

POLLUTION EMISSIONS RESULTING FROM COMBUSTION

Emission factors for aircraft, automobiles, domestic fuel combustion, power plants, and incinerators for several pollutants are given in Tables 17 and 18. The only available data on pollution emissions from jet aircraft that are based on source sampling were obtained by the Los Angeles County Air Pollution Control District.[7] The tests were performed on jet engines designed for water-assisted takeoffs. The emission factors given for jet aircraft without water injection engines were derived

Table 15. SUMMARY OF COMPLAINT RECORDS AND LAND USE NEAR AIRPORTS IN SOME MAJOR CITIES (1962-1964)

City and airport	Distance from airport, miles	Land use	Number and type of complaint
San Francisco (International)	0-1	Light industrial, commercial	1 in 1964. Smoke.
	1-2	Light industrial, commercial, sparse residential	None.
	2-3	Sparse residential	1 in 1964. Settled material.
Boston, (Logan International)	0-1	Dense residential, commercial, light and heavy industrial	2 in 1964. Odors and smoke.
	1-2	Dense residential, commercial, light and heavy industrial	None
	2-3	Dense residential, commercial, light and heavy industrial	None
Los Angeles (International)	0-1	Dense residential, commercial, light and heavy industrial	None
	1-2	Dense residential, commercial, light industrial	None
	2-3	"	None
Detroit (Metropolitan)	0-1	Sparse residential	None
	1-2	Sparse residential, light industrial	None
	2-3	Sparse residential, commercial	None
Detroit (Municipal)	0-1	75% residential, dense 10% commercial 10% light industrial 5% heavy industrial	Dust (number not indicated).
	1-2	70% residential, dense 10% commercial 10% light industrial 10% heavy industrial	None
	2-3	70% residential, dense 5% commercial 10% light industrial 15% heavy industrial	None
St. Louis (Municipal)	0-1	Heavy industrial, commercial, sparse residential	None
	1-2	Heavy industrial, residential, light industrial, industrial, farming and commercial	None
	2-3	Light industrial, residential, farming and commercial	None
Chicago (O'Hare)	0-1	Sparse residential	None
	1-2	Sparse to dense residential	None
	2-3	" " "	None
	3-5	No information	1 in 1962 and 4 in 1963. Smoke
Pittsburgh (Allaghany Cty)	0-1	Semi-rural	None
	1-2	Sparse residential	None
	2-3	" "	None

Table 15. RECORD OF PUBLIC COMPLAINTS ATTRIBUTED TO AIRCRAFT OPERATIONS AT J. F. KENNEDY AIRPORT, N. Y. 1962-1964

Distance from airport, miles	Land use	Number and type of complaints		
		1962	1963	1964
within 1	Sparse residential, commercial and light residential	1 oil 2 soot 1 kerosene odor and discoloration of home Total - 4	1 oil vapor and fumes from fuel depot 1 smoke 1 kerosene fumes and odor Total - 3	1 kerosene odors 1 smoke 4 fumes from jets 1 jet exhaust Total - 7
1 - 2	Dense residential and commercial	None	Jet exhaust fumes and heavy black smoke Total - 1	Smoke Total - 1
2 - 3	Dense residential and commercial	None	1 kerosene odor 1 smoke 1 particulate or soot 1 jet exhaust Total - 4	Smoke Total - 1

from the same Los Angeles data in a manner described by the San Francisco Bay Area Air Pollution Control District.[13] This was done by applying the emission factors obtained during the climbout stage, when there is no water injection, to the takeoff stage. The emission factors obtained in this manner for jet aircraft with no water added during takeoffs is about the same as with water injection for aldehydes and hydrocarbons; it is lower for carbon monoxide and particulates and higher for oxides of nitrogen.

The average daily jet-aircraft operations (landings or takeoffs) at the J. F. Kennedy Airport during the study period was 468, and the average daily 4-engine piston-aircraft operations was 231. A jet-aircraft operation consumes approximately 500 gallons of jet fuel[7] and a 4-engine piston aircraft uses about 90 gallons of aviation fuel.[12] The Los Angeles report indicated that the time required by 4-engine jet aircraft to reach an altitude of 3500 feet is 3.2 minutes. This is in reasonable agreement with data provided by FAA on jet-aircraft operations at John F. Kennedy International Airport.[30]

Based on estimated emission factors and estimated fuel consumption, the total daily particulate emission from aircraft operations below 3500 feet at the J. F. Kennedy Airport, including both landing and takeoff, is 12,100 pounds. This is approximately equivalent to particulate emissions produced by 17,200 housing units burning coal and 190,000 housing units burning oil during an average winter-heating degree-day (30°-day), or to the amount of particulates emitted per day by 600,000 automobiles, one 250 megawatt power plant (10% ash, 96% control), and 2 municipal incinerators, each burning 500 tons of refuse per day. The daily fuel consumption

Table 17. ESTIMATED EMISSION FACTORS FOR AIRCRAFT (BELOW 3500 FEET), AUTOMOBILES, AND DOMESTIC FUEL COMBUSTION

Pollutant	Jet aircraft with water injection,[a] lbs/1000 gal	Jet aircraft without water injection,[b] lbs/1000 gal	Piston aircraft 4 engines lbs/1000 gal[b]	Automobiles,[b] lbs/1000 gal	Domestic use		
					Coal,[c] lbs/ton	Gas,[c] lbs/million cubic ft	Oil,[c] lbs/1000 gal
Aldehydes	6.0	6.0	5.3	4	0.005	Negl.	2.0
Carbon monoxide	64.0	56.0	2,450	2910	50	0.4	2.0
Hydrocarbons	14.5	15.0	491	524[c]	10	Negl.	2.0
Oxides of nitrogen	31.0	37.0	147	113	8	116	36.0
Particulates	62.0	54.0	12.1	11	20	18.7	12.0

[a] Reference number 7.

[b] Reference number 13, includes 126 lbs/1000 gallon blowby emissions.

[c] Reference number 18.

[d] Reference number 13.

Table 18. ESTIMATED EMISSION FACTORS FOR POWER PLANTS AND INCINERATORS

Pollutant	Power plants[a]		Incinerators[b]		
	Coal-fired, lb/ton of coal burned	Oil-fired, lb/1000 gal oil burned	Gas-fired, lb/10 ft of gas burned	Municipal multiple chamber, lb/ton	Flue-fed, lb/ton
Aldehydes	0.005	0.56	1	1.1	4.6
Carbon monoxide	0.5	0.04	Negligible	0.7	na
Hydrocarbons	0.2	3.2	Negligible	1.4	40
Oxides of nitrogen	20	104	390	2.1	0.1
Particulate	16A[c]	8	15	12	26

a. Reference 17.
b. Reference 18.
c. A is percent ash (assuming no emission control equipment used).
e. Not available.

for domestic heating units is estimated by applying the following factors: for coal-fired units, 0.0012 ton of coal per housing unit per degree-day; and for oil-fired units, 0.18 gallon of oil per housing unit per degree-day.

During the summertime, total particulate emissions from all sources in New York City are estimated to be 140 tons per day,[18] and aircraft operations at John F. Kennedy Airport contributed approximately 4.4 percent of this. On an average winter-heating degree-day during the space heating season (30°-day), the estimated quantity of particulate emissions is 335 tons per day, of which aircraft operations at John F. Kennedy Airport contribute 1.9 percent.

Another method of comparing pollution emissions from aircraft operations with total particulate emissions in New York City from all sources is to consider the emissions per square mile of land area. The average particulate emission density for the 320-square-mile area of New York City is approximately 880 pounds per square mile during the nonheating season and approximately 2000 pounds per square mile during the space heating season (30°-day).[18] The particulate emission density due to aircraft operations for the 8-square-mile area of Kennedy International Airport is approximately 1560 pounds per square mile. On a unit area basis, therefore, particulate emissions due to aircraft operations are approximately 1.8 times greater than the city-wide average during the summer and approximately eight-tenths of the city-wide average during the winter. During the spring and fall the emission density attributed to airport land use would be about the same as the average emission density for the city.

These relationships indicate that airport land use results in about the same pollution source strength as exists in the average land area in New York City.

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Appendix

TABULATION OF AIR POLLUTION AND METEOROLOGICAL MEASUREMENTS

TABLE A-1
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
STATION 1

SOILING INDEX, Cohs/1000 ft

DAY	LOCAL TIME 0	2	4	6	8	10
25						
26	.900	1.100	1.300	1.300	1.400	1.400
27	.300	.300	.400	.100	.000	.500
28	.400	.100	.500	.600	.100	.500
29	.600	.200	.300	.300	.700	.600
30	1.000	.800	.500	.700	.900	.300
1	2.400	1.000	.500	1.300	.700	.600
2	.100	.500	.900	.300	.400	.200
3	.500	.400	.700	.300	.700	.500
4	.300	1.000	.600	.400	.300	.000
5	.000	.100	.300	.700	.400	.400
6	.600	1.000	1.000	1.400	1.100	.800
7	3.300	.600	.700	.400	.300	.400
8	1.100	.900	.800	.900	.800	.700
9	.700	1.700	2.500	3.300	2.400	.100
10	.300	1.100	.500	1.200	.700	1.300
11	.300	.000	.000	1.200	.500	.400
12	3.000	4.200	2.700	3.300	1.500	.900
13	.800	.900	1.300	1.700	2.100	2.600
14	3.300	2.600	1.300	2.600	2.600	1.500
15	1.100	.900	1.800	3.200	4.700	2.800
16	1.300	1.200	1.600	2.700	3.400	2.400
17	.500	.100	.600	.500	.300	.600
18	.300	.600	.500	.100	.400	.900
19	1.100	1.700	2.600	4.600		
20	.600	.500	.400	1.100	2.000	1.700
21	.200	.300	.700	1.300	1.200	1.800
22	.000	.600	.700	1.800	2.100	1.000
23	1.300	1.300	1.000	2.400	1.400	1.000
24	.900	1.400	1.500	2.200	2.600	1.600
25	1.300	.400	.900	2.000	2.800	1.600
26	1.400	1.400	2.100	2.200	2.200	1.900
AVG	.965	.965	1.006	1.494	1.357	1.033
N3	31	31	31	31	30	30
M6	3.300	4.200	2.700	4.600	4.700	2.800

N(1) = NO. OF VALID 2 HOUR SAMPLES
MAX(2) = PEAK 2 HOUR CONCENTRATION
N3 = DAYS WITH VALID 2 HOUR AVERAGES
M6 = PEAK 2 HOUR AVERAGES

TABLE A-1 (Continued)
JET AIRCRAFT EXHAUST STUDY SEPT-OCTAB JOHN F. KENNEDY INTERNATIONAL AIRPORT

STATION 1

SOILING INDEX, Cohs/1000 ft

	LOCAL TIME								
DAY	12	14	16	18	20	22	AVG	N(1)	MAX(2)
25	.400	.400	1.100	.400	.400	1.000	.683	6	1.100
26	.900	.600	.200	.300	.300	.400	.808	12	1.400
27	.000	.100	.200	.000	.400	.000	.192	12	.500
28	.500	.300	.900	.700	.400	.700	.475	12	.900
29	.600	.500	.400	.900	.800	1.100	.583	12	1.100
30	.100	.700	.900	.900	1.600	2.600	.917	12	2.600
1	.300	.100	.500	.300	.300	.500	.708	12	2.400
2	.300	.500	.700	.600	.700	.900	.508	12	.900
3	.200	.600	.100	.600	.100	.300	.417	12	.700
4	.600	.000	.300	.900	.300	1.000	.458	12	1.000
5	.300	.200	.300	.500	.600	1.700	.458	12	1.700
6	.200	.200	.600	1.600	2.100	3.600	1.183	12	3.600
7	.600	.000	.100	.900	1.300	.900	.792	12	3.300
8	.400	.300	.100	.200	.700	.000	.575	12	1.100
9	.400	.500	.000	.700	.400	.200	1.075	12	3.300
10	.800	1.300	.600	.800	.600	.800	.833	12	1.300
11	.600	.300	.600	.900	2.100	2.400	.758	12	2.400
12	1.000	.800	.100	.400	.400	.500	1.567	12	4.200
13	1.500	1.100	.800	1.200	2.000	2.800	1.567	12	2.800
14	.700	1.200	1.100	1.300	1.000	.900	1.675	12	3.300
15	1.900	.900	.800	.800	.700	.500	1.675	12	4.700
16	.900	.300	.500	.700	.800	.400	1.350	12	3.400
17	.700	.200	.500	.400	.500	.400	.442	12	.700
18	.700	.900	1.000	1.500	3.100	1.100	.925	12	3.100
19		.600	1.000	1.000	1.100	1.600	1.700	9	4.600
20	.900	.800	1.100	.800	1.000	.200	.925	12	2.000
21	.800	1.000	.900	.500	.300	.500	.792	12	1.800
22	1.000	.900	.700	1.000	1.200	1.000	1.000	12	2.100
23	1.100	.800	.900	.500	1.200	.500	1.133	12	2.600
24	.700	.800	.800	.900	.500	2.000	1.342	12	2.600
25	1.300	1.200	1.100	.900	1.100	1.000	1.300	12	2.800
26							1.900	6	2.200
AVG	.653	.590	.610	.752	.903	1.016			
N3	30	31	31	31	31	31			
M4	1.900	1.300	1.100	1.600	3.100	3.600			

N(1) = NO. OF VALID 2 HOUR SAMPLES
MAX(2) = PEAK 2 HOUR CONCENTRATION
N3 = DAYS WITH VALID 2 HOUR AVERAGES
M4 = PEAK 2 HOUR AVERAGES

Arithmetic mean, all samples - 0.94

Geometric mean, all samples - 0.72

TABLE A-2
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
STATION 4

SOILING INDEX, Cohs/1000 ft

DAY	LOCAL TIME 0	2	4	6	8	10
22						
23	.100	.900	.200	.400	.300	.000
24	1.000	.300	.000	1.200	1.400	.600
25	.200	.400	.600	.600	1.000	.200
26	.400	.800	1.000	2.600	1.700	1.500
27	.200	.300	.200	.300	.100	.200
28	.500	.100	.100	.400	.300	.000
29	.500	.100	.100	.100	.800	.400
30	.400	.700	.300	1.100	.600	.300
1	2.600	1.000	.400	.400	.400	.400
2	.100	1.000	.400	.600	.400	1.100
3	.400	.100	.100	.400	.300	.300
4	1.000	.600	.400	.100	.600	.200
5	.500	.800	.400	1.100	1.300	.200
6	2.800	.200	.200	.200	.100	.200
7	.600	.300	.400	1.000	.700	.700
8	.600	1.300	1.600	1.900	1.400	.600
9	.400	.300	.600	1.700	.600	.100
10	.500	.000	.100	.300	.500	.300
11	2.600	3.700	4.100	5.000	3.400	.700
12	.600	1.200	1.200	1.900	3.300	3.100
13	3.400	3.200	1.600	2.600	1.500	.800
14	1.300	.900	2.000	3.100	4.400	2.100
15	.800	1.100	1.200	2.600	3.600	2.600
16	.100	.100	.300	.100	.500	.100
17	.100	.200	.000	.200	.400	.500
18	1.500	1.700	2.000	3.200	3.300	1.900
19	.200	.200	.200	.900	1.400	.800
20	.100	.100	.000	1.300	1.800	1.300
21	.000	.600	.400	1.400	1.100	.300
22	.600	.400	.700	1.300	.800	.700
23	.500	1.200	.900	1.300	1.600	.700
24	1.300	.600	1.300	2.100	1.900	1.500
25	.700	1.300	1.100	2.000	2.600	2.000
AVG	.806	.765	.739	1.312	1.330	.800
N3	33	33	33	33	33	33
W4	3.400	3.700	4.100	5.000	4.400	3.100

N(1) = NO. OF VALID 2 HOUR SAMPLES
VAR(2) = PEAK 2 HOUR CONCENTRATION
N3 = DAYS WITH VALID 2 HOUR AVERAGES
W4 = PEAK 2 HOUR AVERAGES

TABLE A-2 (Continued)
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
STATION 4

SOILING INDEX, Cohs/1000 ft

	LOCAL TIME								
DAY	12	14	16	18	20	22	AVG	N(1)	MAX(2)
22		.900	.300	.300	.200	.000	.260	5	.500
23	.300	.300	.200	.400	.400	1.000	.333	12	1.000
24	.200	.700	.200	.200	.600	.200	.550	12	1.400
25	.100	.100	.900	.400	.700	.700	.442	12	1.000
26	.400	.200	.400	.000	.500	.500	.833	12	2.600
27	.100	.300	.000	.100	.100	.100	.167	12	.300
28	.200	.100	.700	.400	.200	.700	.308	12	.700
29	.400	.300	.900	.600	1.000	.500	.475	12	1.000
30	.300	.900	.400	.900	1.900	9.000	.867	12	3.000
1	.100	.600	.000	1.000	.500	.200	.650	12	2.600
2	.500	.900	.700	1.100	1.000	.500	.692	12	1.100
3	.100	.100	.200	.200	.600	.300	.258	12	.600
4	.400	.100	.500	.400	1.200	1.200	.558	12	1.200
5	.400	.900	.000	.900	1.000	2.800	.842	12	2.800
6	.200	.300	.000	.800	.600	.400	.500	12	2.800
7	.300	.300	.300	.400	.600	1.000	.550	12	1.000
8	.300	.100	.200	.100	.500	.100	.725	12	1.900
9	.300	.100	.100	.400	.100	.100	.342	12	1.000
10	.300	.100	.700	1.000	1.800	3.100	.725	12	3.100
11	.600	.200	.100	.500	.300	.200	1.783	12	5.000
12	1.900	.900	.700	1.100	1.700	2.700	1.658	12	3.300
13	.600	.600	.200	1.000	1.300	.500	1.442	12	3.400
14	2.200	1.000	.500	.800	.700	.800	1.650	12	4.400
15	.900	.500	.500	1.200	.700	.400	1.342	12	3.600
16	.200	.300	.400	.300	.500	.200	.258	12	.500
17	.200	.300	.500	1.000	1.400	1.200	.500	12	1.400
18	.200	.600	.100	.700	.700	1.000	1.408	12	3.300
19	.600	.500	.800	.900	.700	.400	.633	12	1.400
20	.600	.400	.400	.300	.100	.000	.533	12	1.800
21	.100	.100	.500	.500	.600	.700	.558	12	1.800
22	.300	.400	.800	.000	.300	.700	.583	12	1.300
23	.900	.600	.300	.400	.700	1.300	.850	12	1.400
24	1.100	.500	.800	.300	1.300	.900	1.133	12	2.100
25	1.900	.900					1.913	8	2.600
AVG	.497	.421	.385	.570	.748	.830			
N3	33	34	33	33	33	33			
M4	2.200	1.000	.900	1.200	1.900	9.100			

N(1) = NO. OF VALID 2 HOUR SAMPLES
MAX(2) = PEAK 2 HOUR CONCENTRATION
N3 = DAYS WITH VALID 2 HOUR AVERAGES
M4 = PEAK 2 HOUR AVERAGES

Arithmetic mean, all samples = 0.76

Geometric mean, all samples = 0.52

TABLE A-3
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
STATION 5

SOILING INDEX, Coh/1000 ft

	LOCAL TIME					
DAY	0	2	4	6	8	10

23						
24	1.200	.500	.700	1.500	1.200	.700
25	.400	.800	.700	1.300	1.100	.600
26	.900	.800	1.700	2.200	2.200	1.900
27	.100	.500	.000	.600	.400	.300
28	.600	.300	.300	.600	1.000	.900
29	.700	.600	.300	1.000	.900	.900
30	.700	.900	.700	1.600	1.300	.600
1	2.700	1.000	.500	1.300	.700	.900
2	.700	1.000	.800	.500	.600	.700
3	.700	.300	.600	.600	.800	.700
4	1.000	1.200	.300	.600	.100	.100
5	.300	.000	.600	.300	.600	.100
6	.600	.600	1.000	1.100	1.100	.800
7	2.600	.800	.500	.700	.500	.800
8	.600	.500	.800	2.000	1.100	.600
9	.800	1.600	2.800	2.700	1.900	1.200
10	.700	.300	.500	1.000	.900	.700
11	.300	.100	.100	.200	.700	.300
12	2.200	3.100	3.300	4.700	3.200	1.100
13	1.200	.700	1.500	2.500	4.600	3.200
14	2.800	2.000	1.500	3.000	2.600	1.200
15	1.300	2.600	3.100	4.600	5.000	3.000
16	1.300	1.600	1.800	3.000	4.600	3.100
17	.600	.100	.700	.600	.600	.300
18	.800	.600	.100	.500	.700	.800
19	3.600	2.100	2.000	4.700	4.200	3.300
20	.600	.600	.800	1.800	1.900	1.700
21	.500	.300	.200	1.800	2.100	2.200
22	.100	.600	.600	2.500	2.200	.900
23	.800	1.200	1.100	2.700	2.200	1.600
AVG	1.033	.883	.980	1.727	1.680	1.143
N3	30	30	30	30	30	30
M4	3.600	3.100	3.300	4.700	5.000	3.300

N(1) = NO. OF VALID 2 HOUR SAMPLES
MAX(2) = PEAK 2 HOUR CONCENTRATION
N3 = DAYS WITH VALID 2 HOUR AVERAGES
M4 = PEAK 2 HOUR AVERAGES

TABLE A-3 (Continued)
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
STATION 5

SOILING INDEX, Cohs/1000 ft

	LOCAL TIME								
DAY	12	14	16	18	20	22	AVG	N(1)	MAX(2)
23		.600	1.000	1.700	1.200	1.300	1.160	5	1.700
24	.800	.700	.600	.900	.300	1.000	.800	12	1.500
25	.900	.100	.200	.400	1.000	.700	.650	12	1.300
26	.500	.600	.400	.600	.400	.400	1.050	12	2.200
27	.300	.200	.100	.100	.300	.500	.283	12	.600
28	.500	.300	.400	.600	.800	.600	.558	12	1.000
29	.900	.600	.500	.500	.800	1.300	.733	12	1.300
30	.600	1.000	.700	1.000	2.500	3.200	1.217	12	3.200
1	.200	.400	.200	.100	1.000	.200	.767	12	2.700
2	.400	.900	.400	1.300	1.700	1.200	.833	12	1.700
3	.000	.300	.500	.600	.300	.800	.500	12	.800
4	.400	.500	.700	.600	1.100	.700	.592	12	1.200
5	.500	.600	.600	.800	1.600	1.500	.625	12	1.600
6	.700	.700	.500	.700	1.300	2.100	.900	12	2.100
7	.200	.400	.500	.900	.900	.900	.808	12	2.600
8	.300	.800	.600	.500	1.400	.500	.808	12	2.000
9	.300	.400	.200	.400	.400	.200	1.058	12	2.800
10	.500	.100	.100	.200	.300	.500	.483	12	1.000
11	.700	.600	.900	1.200	2.500	3.200	.900	12	3.200
12	1.300	.900	.600	.600	.200	.400	1.800	12	4.700
13	2.000	1.600	1.300	1.200	1.900	3.000	2.042	12	4.600
14	.800	.800	1.300	1.700	1.100	.800	1.617	12	3.000
15	2.800	1.200	1.400	2.000	.600	1.000	2.367	12	5.000
16	1.900	1.200	1.000	.800	.800	.800	1.825	12	4.600
17	.500	.600	.800	.600	.600	.300	.525	12	.800
18	.500	.600	.500	1.600	1.800	3.600	.992	12	3.600
19	.900	.500	1.000	1.000	.900	1.100	2.108	12	4.700
20	1.600	1.500	1.500	.800	1.000	.800	1.217	12	1.900
21	2.000	.900	.600	.700	.100	.600	.967	12	2.200
22	.500	.800	1.100	1.000	1.000	.800	1.008	12	2.500
23	1.200	.900	.800				1.367	9	2.700
AVG	.810	.687	.671	.843	.987	1.127			
N3	30	31	31	30	30	30			
N4	2.800	1.600	1.500	2.000	2.500	3.600			

N(1) = NO. OF VALID 2 HOUR SAMPLES
MAX(2) = PEAK 2 HOUR CONCENTRATION
N3 = DAYS WITH VALID 2 HOUR AVERAGES
N4 = PEAK 2 HOUR AVERAGES

Arithmetic mean, all samples - 1.04

Geometric mean, all samples - 0.76

TABLE A-4
JET AIRCRAFT EMISSIST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT

STATION H

SOILING INDEX, Coho/1000 ft

	LOCAL TIME										
Day	0		2		4		6		8		10	
15												
16		.200	.200	.200	.700	.500	.200	.200	.500	.400	.200	.200
23											.500	.500
24	.200	.200	.400	.200	1.100	1.300	1.400	1.300	.200	.500	.200	.500
25	.500	.500	.400	.400	.500	.400	1.100	.400	.400	.500	.500	.200
26	.900	1.100	1.100	1.900	2.400	2.800	2.400	2.500	1.900	1.100	.900	1.400
27	.200	.200	.200	.200	.200	.200	.200	.200	.200	.200	.200	.200
28	.200	.200	.200	.200	.400	1.600	1.100	1.300	.800	.200	.500	.500
29	.200	.200	.200	.500	.500	.400	.400	.800	.800	.200	.200	.500
30	.500	.500	.900	.500	.500	1.100	1.100	.500	.500	.500	.200	.800
1	1.300	.400			1.100	1.100	.400	.500	.500	.200	.200	.200
2	1.300	.500	.500	.500	.400	.500	.500	.500	.800	.500	.500	.400
3	.500	.500	.200	.200	.200	.400	.800	.500	.500	.500	.200	.200
4	1.400	.800	.500	.200	.400	.200	.200	.200	.200	.200	.200	.200
5	.900	.500	.500	.500	.500	.400	.400	.500	.500	.500	.500	.500
6	.500	.800	1.100	1.100	1.300	1.100	1.100	1.100	1.100	.500	.500	.900
7		.500	.500	.500	.400							
8	.900	.900	.500									
9												.200
10	.900	.500	.500	.500	.400	.500	.500	.500	.200	.200	.200	.200
11	.200	.500	.500	.500	.400	.500	.500	.500	.500	.500	.500	.500
12	2.500			3.400					.500	.500	.500	
13	.900	.800	.900	1.900	2.400	2.200	3.400	3.400			1.300	1.100
14			1.900	2.200	3.700	3.100	1.400	1.600	.500	.500	.500	.500
15	.800	.800	.900	2.800	3.100					3.500	3.400	.400
16	1.100	1.100	1.100	1.400	2.500	2.800	4.900	4.000	3.100	3.100	2.200	.800
17	.900		.900		.600		.800		.300		.600	
18	.600		.600		.700		.600		.600		.700	
19	1.600		2.300		3.300		3.000		3.500		2.600	
20	.700		.800		.300		2.000		2.000		1.800	
21	.600		.200		.000		.600		2.000		2.600	
22	.900		.200		.300		.700		1.700		2.600	
23	1.600		1.600		1.600		.800		.800		2.000	
24	1.000		1.600		1.600		1.600		1.100		1.600	
25	.600		.700		.600		.600		1.000		1.700	
AVG	.724	.567	.707	.671	1.030	1.195	1.214	1.100	.679	.820	.965	.661
N3	28		30		30		28		28		31	
M4	2.500	1.100	2.300	3.400	3.700	3.100	4.900	4.000	3.500	3.500	3.400	1.600

N(1) = NO. OF VALID 2 HOUR SAMPLES
MAX(2) = PEAK 2 HOUR CONCENTRATION
N3 = DAYS WITH VALID 2 HOUR AVERAGES
M4 = PEAK 2 HOUR AVERAGES

TABLE A-4 (Continued)
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
STATION H
BOILING INDEX, Cohs/1000 ft

	LOCAL TIME														
DAY	12		14		16		18		20		22		AVG	N(1)	MAX(2)
13	1.900	1.800	1.600	1.300	1.900	1.600	2.400	2.800	2.800	2.200	1.800	.900	1.839	12	2.800
14	.200	.900	.900		.600	1.100	.800	.500	.900				.421	10	1.100
23	.400	.500	.900	.900	1.900	1.100	1.100	.900	1.100	.900	1.600	.600	.820	14	1.900
24	.200	.200	.900	.200	.600	.600	.900	.900	.900	.900	.900	.200	.525	24	1.600
25	.400	.200	.900	.900	.900	.800	.900	.800	.900	.900	1.100	.800	.613	24	1.100
26	1.600	.200	.200	.200	.200	.900	1.100	.200	.200	.200	.200	.200	1.050	24	2.800
27	.200	.200	.200	.200	.200	.200	.200	.900	.200	.200	.200	.900	.225	24	.900
28	.900	.200	.900	.200	.200			.900	.800	.900	.800	.800	.559	22	1.600
29	.900	.900	.200	.900	.900	.700	.800	1.100	1.600	1.100	.800	.800	.596	24	1.600
30	.900	.600	.900	.800	1.100	1.900	2.700	1.900	2.800	5.200		2.800	1.217	23	5.200
1	.200	.200	.200	.200	.200	.700	.900	.900	.900	.900	.200	.200	.495	22	1.300
2	.900	.600	.800	.900	.900	1.900	1.600	1.300	1.600	.900	.900	.200	.717	24	1.600
3	.200	.200	.200	.200	.900	.900	.900	.900	.800	.800	.800	1.600	.688	24	1.600
4	.200	.200	.200	.800	.900	.900	.800	.900	.900	.200	.200	.200	.600	24	1.600
5	.900	.900	.900	.900	.900	.200	.900	.900	.900	.900	.900		.513	23	.800
6	.900	.900	.900	.900	.900	.600	.900	.800	1.600				.790	21	1.600
7												.900	.900	5	.900
8													.900	1	.900
9	.200	.200	.200	.900	.900	.900	.900	.200	.200	.200	.200	.600	.319	19	.900
10	.200	.200	.200	.200	.200	.900	.200	.200	.900	.200	.200	.200	.338	24	.800
11	.200	.200	.900	.900	.900	1.100	1.100	1.900	2.200	1.900	2.200	2.900	.854	24	2.900
12		.900	.200	.200	.200	.900	.200	.200	.900	.900	.900	.800	.713	16	3.600
13	1.600	1.100	.600	1.100	1.600	1.600	2.200	2.200	4.300	6.900	4.900	6.900	2.600	22	6.900
14	.600	.900	.600	.600	.600	.800	1.100	.900	.800	1.100	.800	.800	1.150	22	3.700
15	1.900	1.100	1.100	1.100	1.100	.900	.900	.900	.800	.800	.800	1.100	1.425	20	3.900
16	1.100		.800		.800		.600		.600		.600		1.811	18	4.900
17	.900		.900		.600		.900		.900		.700		.450	12	.800
18	.900		.600		.600		.600		.600		.800		.597	12	.800
19	.800		1.600		1.100		1.600		1.100		1.100		1.917	12	3.900
20	1.600		.800		1.600		.900		.800		.800		1.139	12	2.000
21	2.900		.700		.900		.900		.900		.600		.842	12	2.600
22	1.700		.800		1.900		1.600		1.800		2.200		1.233	12	2.600
23	3.000		1.600		.800		.900		.700		1.000		1.250	12	3.000
24	2.200		1.800		1.600		.800		.700		.800		1.319	12	2.200
25	2.900		3.000		2.600								1.633	9	3.000
AVG	.884	.683	.891	.914	.779	.795	.844	.830	1.013	1.171	.931	1.081			
n3	32		33		33		31		32		29				
n4	3.000	1.800	3.000	1.900	2.600	1.900	2.900	2.800	4.300	6.900	4.900	6.900			

N(1) = NO. OF VALID 2 HOUR SAMPLES
MAX(2) = PEAK 2 HOUR CONCENTRATION
n3 = DAYS WITH VALID 2 HOUR AVERAGES
n4 = PEAK 2 HOUR AVERAGES

Arithmetic mean, all samples = 0.86

Geometric mean, all samples = 0.61

Table A5. TOTAL SUSPENDED PARTICULATE CONCENTRATION, $\mu g/m^3$

Date, 1964	Station Number					
	1	2	3	4	5	6
September						
24	107	n.d.	117	n.d.	207	192
25	121	n.d.	129	n.d.	207	110
28	45	n.d.	42	39	59	28
29	35	88	28	41	60	31
30	67	80	42	86	122	79
October						
1	43	40	57	55	74	51
2	78	35	37	49	63	35
3	49	56	n.d.	59	85	43
4*	49	56	n.d.	59	85	43
5	59	48	47	56	88	53
6	103	92	60	89	128	67
7	48	47	49	54	77	48
8	66	66	72	79	106	50
9	52	n.d.	n.d.	56	79	45
10	109	n.d.	n.d.	225	158	83
11*	109	n.d.	n.d.	225	158	83
12	102	148	n.d.	147	158	117
13	175	230	201	202	236	153
14	158	200	184	193	287	165
15	136	226	144	163	214	108
16*	136	n.d.	144	163	214	108
17	70	n.d.	76	101	136	79
18*	70	n.d.	76	101	136	79
19	75	n.d.	62	72	117	64
20	52	n.d.	57	70	110	54
21	85	106	84	84	133	67
22	76	71	68	70	130	82
23	82	79	72	n.d.	n.d.	84
Arithmetic mean	84	98	84	102	133	76
Geometric mean	77	83	73	88	122	68
Maximum	175	230	201	225	287	192
Minimum	35	35	28	39	59	28

* Second day of 48-hour sample. The 48-hour average concentration measured is divided equally between both days for the purpose of stating 24-hour concentrations.

TABLE A-6
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
STATION 5
TOTAL HYDROCARBONS ppm

DAY	LOCAL TIME 0	1	2	3	4	5	6	7	8	9	10	11
15												
16		2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	3.000	3.000	3.000
17	9.000	8.000	8.000	7.000	6.000	4.000	3.000	3.000	3.000	3.000	3.000	3.000
18	8.000	9.000	5.000	4.000	4.000	5.000	5.000	4.000	4.000	3.000	3.000	2.000
19	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
20	3.000	3.000	3.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
21	3.000	3.000	3.000	3.000	3.000	3.000	3.000	2.000	2.000	2.000		
22	3.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
23	4.000	3.000	3.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
24	3.000	3.000	2.000	2.000	3.000	8.000	5.000	3.000	2.000		3.000	3.000
25	3.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
26	5.000	5.000	5.000	10.000	7.000	10.000	7.000	4.000	4.000	3.000	2.000	2.000
27	2.000	2.000	3.000	3.000	3.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
28	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
29	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
30	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
1	3.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	4.000	4.000
2	3.000	3.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
3	5.000	4.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
4	9.000	9.000	6.000	4.000	3.000	2.000	2.000	2.000	2.000	2.000	2.000	3.000
5	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
6	3.000	3.000	3.000	3.000	3.000	3.000	3.000	2.000	2.000	2.000	2.000	2.000
7	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
8	3.000	2.000	2.000	2.000	3.000	3.000	2.000	2.000	2.000	2.000	2.000	2.000
9	4.000	5.000	5.000	6.000	5.000	5.000	4.000	3.000	2.000	2.000	2.000	2.000
10	3.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
11	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
12	6.000	7.000	9.000	11.000	11.000	13.000	13.000	4.000	4.000	3.000	2.000	2.000
13	4.000	4.000	4.000	5.000								
14	10.000	8.000	5.000	5.000	5.000	4.000	4.000	2.000	2.000	2.000	2.000	2.000
15	11.000	9.000	9.000	13.000	16.000	14.000	12.000	8.000	3.000	3.000	3.000	3.000
16	5.000	5.000	5.000	6.000	8.000	9.000	8.000	7.000	5.000			
17	4.000	3.000	3.000	3.000	3.000	2.000	2.000	3.000	3.000	3.000	2.000	2.000
18	2.000	2.000	2.000	2.000	2.000	2.000	2.000	3.000	2.000	2.000	2.000	2.000
19	15.000	13.000	11.000	12.000	17.000	20.000	14.000	9.000	5.000	5.000	3.000	2.000
20	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
21	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
22	2.000	3.000	5.000	4.000	5.000	7.000	3.000	3.000	2.000	2.000	2.000	2.000
23	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	2.000	2.000	2.000	2.000

TABLE A-6 (Continued)
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT

STATION 5

TOTAL HYDROCARBONS, ppm

		LOCAL TIME										
DAY	0	1	2	3	4	5	6	7	8	9	10	11
24		3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	2.000	2.000	2.000
25	6.000	5.000	7.000	5.000	5.000	5.000	7.000	6.000	4.000	3.000	3.000	3.000
26	5.000	5.000	8.000	8.000	14.000	11.000	10.000	7.000	6.000	5.000	5.000	4.000
AVG	4.282	3.902	3.756	3.902	4.200	4.350	3.825	3.025	2.550	2.368	2.316	2.263
N3	39	41	41	41	40	40	40	40	40	38	38	38
M4	15.000	13.000	11.000	13.000	17.000	20.000	14.000	9.000	6.000	5.000	5.000	4.000

N(1) = HOURS OF VALID DATA
MAX(2) = PEAK 30 MIN. CONCENTRATION
N3 = DAYS WITH VALID HOURLY AVERAGES
M4 = PEAK HOURLY AVERAGES

TABLE A-6 (Continued)
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
STATION 5

TOTAL HYDROCARBONS, ppm

	LOCAL TIME														
DAY	12	13	14	15	16	17	18	19	20	21	22	23	AVG	N(1)	MAX(2)
15	2.000	2.000	2.000	2.000	2.000	3.000	4.000	3.000	3.000	3.000	2.000	2.000	2.500	12	4.000
16	3.000	2.000	2.000		10.000	10.000	10.000	10.000	10.000	10.000	10.000	9.000	5.045	22	10.000
17	3.000	3.000	3.000	3.000	3.000	3.000	4.000	5.000	5.000	7.000	17.000	10.000	5.250	24	17.000
18	2.000	2.000	2.000	2.000	2.000	2.000	3.000	2.000	3.000	3.000	3.000	3.000	3.542	24	9.000
19	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	3.000	3.000	2.083	24	3.000
20	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	3.000	3.000	3.000	3.000	2.292	24	3.000
21				2.000	2.000	2.000	2.000	6.000	5.000	4.000	4.000	3.000	3.000	19	6.000
22	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	4.000	2.125	24	4.000
23	2.000	2.000	2.000	3.000	3.000	3.000	4.000	4.000	4.000	5.000	6.000	4.000	2.917	24	6.000
24	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.174	23	8.000
25	2.000	2.000	2.000	2.000	3.000	3.000	3.000	3.000	3.000	3.000	4.000	4.000	2.458	24	4.000
26	2.000	2.000	2.000	2.000	2.000	3.000	4.000	3.000	3.000	3.000	3.000	2.000	3.958	24	10.000
27	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.125	24	3.000
28	2.000	2.000	2.000	2.000	3.000	2.000	2.000	3.000	3.000	3.000	3.000	3.000	2.250	24	3.000
29	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	24	2.000
30	2.000	2.000	2.000	2.000	2.000	3.000	5.000	7.000	9.000	10.000	8.000	6.000	3.417	24	10.000
1	3.000	2.000	3.000	2.000	2.000	2.000	2.000	2.000	3.000	3.000	3.000	3.000	2.458	24	4.000
2	2.000	2.000	3.000	3.000	3.000	3.000	3.000	4.000	4.000	5.000	6.000	5.000	2.875	24	6.000
3	2.000	2.000	2.000	3.000	4.000	4.000	7.000	8.000	7.000	6.000	7.000	7.000	3.667	24	8.000
4	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	2.000	2.000	2.000	2.000	3.250	24	9.000
5	2.000	2.000	2.000	2.000	2.000	3.000	5.000	5.000	5.000	3.000	3.000	3.000	2.542	24	5.000
6	2.000	2.000	2.000	2.000	2.000	2.000	3.000	3.000	4.000	6.000	8.000	4.000	2.958	24	8.000
7	2.000	2.000	2.000	2.000	2.000	2.000	5.000	5.000	4.000	3.000	3.000	3.000	2.458	24	5.000
8	2.000	2.000	2.000	2.000	2.000	4.000	2.000	3.000	5.000	4.000	3.000	5.000	2.625	24	5.000
9	2.000	2.000	2.000	2.000	2.000	2.000	2.000	4.000	4.000	4.000	5.000	4.000	3.333	24	6.000
10	2.000	3.000	3.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.125	24	3.000
11	2.000	2.000	2.000	2.000	3.000	3.000	4.000	6.000	6.000	5.000	5.000	5.000	2.875	24	6.000
12	2.000	2.000	2.000	2.000	3.000	3.000	5.000	6.000	5.000	5.000	5.000	5.000	5.417	24	13.000
13		2.000	2.000	2.000	2.000	2.000	4.000	4.000	6.000	8.000	10.000	13.000	4.800	15	13.000
14	2.000	2.000	2.000	2.000	2.000	2.000	2.000	3.000	7.000	8.000	6.000	7.000	4.000	24	10.000
15	3.000	3.000	3.000	2.000	2.000	3.000	4.000	5.000	6.000	6.000	6.000	5.000	6.333	24	16.000
16	3.000	3.000	4.000	3.000	3.000	6.000	3.000	3.000	3.000	6.000	6.000	5.000	5.143	21	9.000
17	2.000	2.000	2.000	2.000	2.000	2.000	3.000	3.000	3.000	3.000	3.000	3.000	2.625	24	4.000
18	2.000	2.000	2.000	3.000	4.000	4.000	5.000	7.000	9.000	11.000	13.000	11.000	4.083	24	13.000
19	2.000	2.000	2.000	2.000	2.000	2.000	2.000	3.000	4.000	4.000	3.000	3.000	6.542	24	20.000
20	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	24	2.000
21	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	24	2.000
22	2.000	2.000	2.000	2.000	2.000	2.000	2.000	3.000	4.000	4.000	3.000	3.000	2.958	24	7.000
23	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	4.000	4.000	3.000	3.000	2.583	24	4.000

TABLE A-6 (Continued)
JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
STATION 5
TOTAL HYDROCARBONS, ppm

	LOCAL TIME													
DAY	12	13	14	15	16	17	18	19	20	21	22	23	AVG	N(1)	MAX(2)
24	2.000	2.000	2.000	2.000	2.000	3.000	3.000	3.000	4.000	5.000	6.000	8.000	3.125	24	8.000
25	3.000	3.000	3.000	3.000	3.000	4.000	4.000	5.000	5.000	7.000	6.000	7.000	4.667	24	7.000
26													7.333	12	14.000
AVG	2.205	2.175	2.300	2.225	2.561	2.829	3.293	3.780	4.195	4.463	4.780	4.429			
N3	39	40	40	40	41	41	41	41	41	41	41	42			
M4	3.000	3.000	6.000	3.000	10.000	10.000	10.000	10.000	10.000	11.000	17.000	13.000			

N(1) = HOURS OF VALID DATA
MAX(2) = PEAK 30 MIN. CONCENTRATION
N3 = DAYS WITH VALID HOURLY AVERAGES
M4 = PEAK HOURLY AVERAGES

Arithmetic mean, all samples - 3.35

Geometric mean, all samples - 2.88

GPO 826-782-4

TABLE A-7. JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT HANGER 11

WIND SPEED
*RAN
UNITS= MPH

	LOCAL TIME											
DAY	0	1	2	3	4	5	6	7	8	9	10	11
24	7.000	10.000	14.000	16.000	15.000	6.000	3.000	7.000	8.000	10.000	12.000	13.000
25	14.000	13.000	9.000	10.000	13.000	14.000	13.000	16.000	15.000	18.000	15.000	18.000
26	5.000	6.000	5.000	3.000	3.000	5.000	5.000	6.000	.000	5.000	3.000	9.000
27	9.000	9.000	8.000	7.000	9.000	9.000	14.000	17.000	20.000	21.000	22.000	22.000
28	17.000	17.000	18.000	14.000	14.000	14.000	10.000	5.000	8.000	5.000	1.000	5.000
29	7.000	7.000	9.000	10.000	4.000	9.000	6.000	7.000	8.000	7.000	7.000	5.000
30	7.000	9.000	9.000	9.000	6.000	5.000	2.000	5.000	7.000	12.000	9.000	9.000
1	8.000	6.000	9.000	8.000	9.000	6.000	6.000	10.000	9.000	12.000	9.000	12.000
2	8.000	7.000	6.000	5.000	7.000	6.000	9.000	7.000	8.000	10.000	8.000	7.000
3	10.000	8.000	13.000	20.000	14.000	12.000	12.000	7.000	9.000	9.000	7.000	12.000
4	9.000	10.000	7.000	7.000	9.000	8.000	13.000	9.000	12.000	13.000	12.000	12.000
5	14.000	13.000	16.000	12.000	9.000	10.000	10.000	12.000	9.000	13.000	14.000	9.000
6	3.000	5.000	6.000	5.000	5.000	6.000	8.000	7.000	8.000	7.000	2.000	3.000
7	.000	10.000	13.000	13.000	15.000	8.000	12.000	14.000	16.000	16.000	15.000	15.000
8	8.000	8.000	7.000	8.000	7.000	8.000	8.000	9.000	12.000	9.000	7.000	12.000
9	.000	3.000	.000	.000	.000	3.000	5.000	.000	5.000	2.000	3.000	7.000
10	8.000	13.000	12.000	7.000	9.000	9.000	14.000	14.000	14.000	12.000	14.000	13.000
11	17.000	14.000	14.000	21.000	14.000	16.000	17.000	17.000	16.000	14.000	12.000	10.000
12	3.000	.000	.000	.000	.000	2.000	2.000	2.000	7.000	9.000	9.000	14.000
13	13.000	13.000	12.000	9.000	12.000	9.000	6.000	5.000	6.000	5.000	6.000	6.000
14	.000	3.000	5.000	3.000	5.000	6.000	6.000	.000	6.000	12.000	9.000	9.000
15	6.000	8.000	3.000	3.000	3.000	5.000	8.000	6.000	6.000	6.000	8.000	6.000
16	6.000	7.000	7.000	6.000	3.000	.000	5.000	5.000	2.000	5.000	1.000	2.000
17	13.000	14.000	13.000	14.000	14.000	17.000	18.000	12.000	10.000	20.000	21.000	21.000
18	13.000	16.000	12.000	14.000	10.000	12.000	10.000	8.000	8.000	9.000	14.000	12.000
19	6.000	6.000	5.000	5.000	6.000	8.000	5.000	2.000	6.000	7.000	10.000	14.000
20	3.000	7.000	7.000	6.000	3.000	5.000	7.000	5.000	2.000	5.000	5.000	3.000
21	13.000	15.000	13.000	12.000	6.000	7.000	7.000	5.000	6.000	9.000	9.000	7.000
22	14.000	14.000	13.000	8.000	8.000	7.000	8.000	6.000	8.000	13.000	14.000	9.000
23	6.000	10.000	7.000	7.000	8.000	6.000	7.000	7.000	12.000	12.000	13.000	9.000
24	10.000	12.000	10.000	8.000	7.000	7.000	8.000	7.000	7.000	8.000	9.000	10.000
AVG	8.645	9.419	9.161	8.742	8.355	7.871	8.581	7.710	8.710	10.161	9.677	10.161
M3	31	31	31	31	31	31	31	31	31	31	31	31
M4	17.000	17.000	18.000	21.000	14.000	17.000	18.000	17.000	20.000	21.000	22.000	22.000

M(1) = HOURS OF VALID DATA
MAX(2) = PEAK 1 HOUR CONCENTRATION
M3 = DAYS WITH VALID HOURLY AVERAGES
M4 = PEAK HOURLY AVERAGES

TABLE A-7 (cont'd) JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
HANGER 11

WIND SPEED
WBAN
UNITS= MPH

	LOCAL TIME														
DAY	12	13	14	15	16	17	18	19	20	21	22	23	AVG	N(1)	MAX(2)
24	15.000	12.000	20.000	20.000	29.000	21.000	14.000	14.000	14.000	14.000	12.000	12.000	13.208	24	28.000
25	18.000	18.000	18.000	17.000	19.000	9.000	12.000	9.000	10.000	16.000	9.000	9.000	13.792	24	18.000
26	10.000	10.000	12.000	14.000	17.000	16.000	15.000	18.000	15.000	12.000	14.000	9.000	9.042	24	18.000
27	23.000	23.000	28.000	29.000	26.000	21.000	23.000	20.000	13.000	14.000	12.000	13.000	17.250	24	29.000
28	1.000	3.000	3.000	5.000	7.000	5.000	6.000	9.000	5.000	5.000	5.000	8.000	8.000	24	18.000
29	7.000	6.000	3.000	9.000	9.000	10.000	6.000	9.000	5.000	9.000	8.000	6.000	7.292	24	10.000
30	12.000	9.000	9.000	7.000	12.000	7.000	5.000	5.000	2.000	.000	3.000	6.000	6.917	24	12.000
1	15.000	14.000	12.000	10.000	9.000	12.000	9.000	9.000	5.000	8.000	8.000	6.000	9.167	24	15.000
2	8.000	6.000	9.000	6.000	7.000	3.000	2.000	1.000	1.000	.000	6.000	6.000	5.958	24	10.000
3	12.000	12.000	9.000	12.000	7.000	9.000	5.000	7.000	8.000	13.000	8.000	12.000	10.375	24	20.000
4	8.000	8.000	9.000	9.000	12.000	9.000	13.000	9.000	9.000	7.000	14.000	16.000	10.167	24	16.000
5	13.000	7.000	8.000	6.000	6.000	6.000	5.000	5.000	3.000	5.000	5.000	7.000	9.042	24	16.000
6	6.000	7.000	3.000	8.000	7.000	3.000	5.000	2.000	.000	.000	3.000	.000	4.750	24	8.000
7	12.000	12.000	12.000	9.000	3.000	5.000	7.000	5.000	7.000	9.000	6.000	12.000	10.125	24	16.000
8	7.000	1.000	8.000	9.000	6.000	5.000	5.000	5.000	7.000	3.000	10.000	5.000	7.167	24	12.000
9	9.000	8.000	9.000	13.000	13.000	12.000	12.000	7.000	9.000	8.000	10.000	7.000	6.042	24	13.000
10	14.000	14.000	16.000	15.000	15.000	16.000	21.000	21.000	16.000	22.000	16.000	16.000	14.208	24	22.000
11	14.000	8.000	7.000	6.000	10.000	10.000	9.000	3.000	3.000	3.000	3.000	2.000	11.000	24	21.000
12	9.000	8.000	12.000	14.000	14.000	10.000	8.000	9.000	10.000	12.000	8.000	9.000	7.125	24	14.000
13	8.000	9.000	9.000	10.000	5.000	.000	10.000	6.000	3.000	3.000	.000	.000	6.875	24	13.000
14	3.000	6.000	7.000	5.000	8.000	8.000	6.000	8.000	6.000	3.000	6.000	6.000	5.667	24	12.000
15	8.000	8.000	12.000	15.000	14.000	14.000	9.000	7.000	7.000	5.000	9.000	7.000	7.625	24	15.000
16	9.000	14.000	9.000	7.000	8.000	7.000	6.000	10.000	10.000	8.000	10.000	13.000	6.667	24	14.000
17	18.000	18.000	20.000	18.000	18.000	18.000	16.000	17.000	16.000	16.000	14.000	12.000	16.250	24	21.000
18	9.000	10.000	10.000	9.000	8.000	5.000	10.000	5.000	6.000	5.000	7.000	6.000	9.583	24	16.000
19	14.000	15.000	15.000	17.000	13.000	12.000	13.000	10.000	9.000	7.000	6.000	10.000	9.167	24	17.000
20	3.000	3.000	5.000	7.000	8.000	7.000	9.000	14.000	7.000	12.000	10.000	12.000	6.958	24	14.000
21	13.000	14.000	10.000	12.000	12.000	18.000	20.000	21.000	21.000	22.000	16.000	24.000	12.917	24	24.000
22	9.000	12.000	9.000	10.000	9.000	16.000	9.000	12.000	10.000	12.000	7.000	10.000	10.333	24	16.000
23	13.000	7.000	12.000	15.000	15.000	16.000	15.000	16.000	12.000	23.000	17.000	14.000	11.667	24	23.000
24	12.000	12.000	15.000	13.000	13.000	17.000	21.000	14.000	12.000	10.000	10.000	9.000	10.875	24	21.000
AVG	10.710	10.179	10.968	11.484	11.516	10.548	10.516	9.903	8.419	9.226	8.774	9.161			
N3	31	31	31	31	31	31	31	31	31	31	31	31			
M4	23.000	23.000	28.000	29.000	28.000	21.000	23.000	21.000	21.000	23.000	17.000	24.000			

N(1) = HOURS OF VALID DATA
MAX(2) = PEAK 1 HOUR CONCENTRATION
N3 = DAYS WITH VALID HOURLY AVERAGES
M4 = PEAK HOURLY AVERAGES

TABLE A-8. JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
HANGER 11

WIND DIRECTION
#BAN
UNITS= ANGULAR DEG.

	LOCAL TIME											
DAY	0	1	2	3	4	5	6	7	8	9	10	11
24	240.000	280.000	300.000	320.000	310.000	320.000	270.000	260.000	260.000	260.000	230.000	230.000
25	270.000	300.000	260.000	260.000	270.000	260.000	290.000	290.000	260.000	260.000	270.000	250.000
26	310.000	260.000	260.000	280.000	290.000	280.000	280.000	270.000	.000	220.000	220.000	180.000
27	230.000	210.000	210.000	210.000	200.000	200.000	190.000	190.000	190.000	190.000	190.000	190.000
28	260.000	330.000	350.000	330.000	360.000	350.000	350.000	350.000	40.000	50.000	40.000	40.000
29	50.000	60.000	60.000	70.000	10.000	50.000	40.000	40.000	50.000	40.000	50.000	60.000
30	10.000	10.000	30.000	10.000	40.000	10.000	10.000	20.000	20.000	360.000	40.000	40.000
1	10.000	10.000	10.000	10.000	30.000	40.000	40.000	60.000	70.000	60.000	90.000	110.000
2	110.000	90.000	40.000	40.000	50.000	70.000	80.000	90.000	90.000	80.000	80.000	90.000
3	200.000	210.000	240.000	340.000	320.000	330.000	330.000	310.000	320.000	320.000	300.000	280.000
4	240.000	250.000	240.000	230.000	230.000	220.000	220.000	220.000	230.000	230.000	230.000	230.000
5	350.000	330.000	340.000	350.000	340.000	330.000	360.000	350.000	30.000	10.000	30.000	360.000
6	10.000	20.000	360.000	30.000	10.000	10.000	350.000	360.000	10.000	20.000	60.000	70.000
7	.000	320.000	350.000	360.000	10.000	40.000	40.000	20.000	20.000	20.000	40.000	30.000
8	20.000	20.000	20.000	20.000	20.000	20.000	10.000	20.000	20.000	30.000	50.000	40.000
9	.000	70.000	.000	.000	.000	20.000	40.000	.000	80.000	230.000	190.000	170.000
10	260.000	300.000	300.000	300.000	290.000	300.000	300.000	300.000	310.000	310.000	320.000	310.000
11	320.000	320.000	310.000	340.000	340.000	340.000	320.000	350.000	340.000	320.000	340.000	330.000
12	340.000	.000	.000	.000	.000	300.000	290.000	250.000	250.000	230.000	230.000	240.000
13	250.000	250.000	270.000	260.000	260.000	250.000	240.000	240.000	240.000	240.000	230.000	230.000
14	.000	300.000	290.000	280.000	320.000	320.000	270.000	.000	320.000	320.000	330.000	10.000
15	210.000	240.000	260.000	230.000	220.000	220.000	250.000	220.000	250.000	280.000	260.000	230.000
16	230.000	230.000	230.000	210.000	220.000	.000	200.000	320.000	50.000	150.000	210.000	70.000
17	50.000	50.000	40.000	50.000	60.000	40.000	60.000	40.000	30.000	40.000	50.000	60.000
18	20.000	20.000	360.000	10.000	10.000	360.000	360.000	10.000	10.000	360.000	350.000	350.000
19	240.000	230.000	230.000	220.000	220.000	250.000	240.000	270.000	350.000	250.000	270.000	340.000
20	340.000	330.000	350.000	330.000	350.000	280.000	300.000	310.000	350.000	30.000	60.000	360.000
21	360.000	10.000	360.000	360.000	330.000	330.000	320.000	310.000	270.000	250.000	260.000	240.000
22	210.000	230.000	240.000	250.000	240.000	270.000	270.000	280.000	260.000	310.000	310.000	320.000
23	360.000	350.000	360.000	330.000	330.000	320.000	330.000	340.000	350.000	10.000	350.000	10.000
24	330.000	320.000	340.000	360.000	330.000	330.000	300.000	290.000	290.000	300.000	310.000	290.000
N3	31	31	31	31	31	31	31	31	31	31	31	31

N(1) = HOURS OF VALID DATA
N3 = DAYS WITH VALID HOURLY AVERAGES

TABLE A-8 (cont'd) JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT HANGER 11

WIND DIRECTION
AVAN
UNITS= ANGULAR DEG.

	LOC L TIME												
DAY	12	13	14	15	16	17	18	19	20	21	22	23	N(1)
24	230.000	230.000	230.000	240.000	250.000	260.000	270.000	270.000	280.000	290.000	290.000	280.000	24
25	260.000	270.000	270.000	290.000	310.000	300.000	290.000	280.000	250.000	290.000	300.000	290.000	24
26	190.000	190.000	190.000	170.000	190.000	180.000	180.000	190.000	200.000	210.000	210.000	230.000	24
27	190.000	180.000	190.000	190.000	190.000	190.000	190.000	200.000	200.000	200.000	220.000	230.000	24
28	50.000	50.000	10.000	20.000	60.000	120.000	130.000	100.000	60.000	50.000	60.000	50.000	24
29	60.000	60.000	70.000	90.000	90.000	90.000	90.000	80.000	260.000	350.000	360.000	50.000	24
30	360.000	360.000	10.000	10.000	10.000	10.000	360.000	340.000	360.000	.000	10.000	360.000	24
1	110.000	110.000	110.000	120.000	120.000	110.000	100.000	90.000	100.000	100.000	110.000	110.000	24
2	90.000	90.000	80.000	60.000	80.000	40.000	60.000	60.000	30.000	.000	210.000	200.000	24
3	320.000	320.000	310.000	320.000	270.000	270.000	230.000	230.000	240.000	240.000	230.000	240.000	24
4	240.000	230.000	190.000	220.000	220.000	210.000	240.000	260.000	260.000	280.000	340.000	340.000	24
5	20.000	360.000	10.000	360.000	10.000	20.000	40.000	40.000	30.000	360.000	20.000	20.000	24
6	50.000	320.000	320.000	180.000	190.000	150.000	150.000	130.000	.000	.000	70.000	.000	24
7	360.000	360.000	340.000	360.000	350.000	360.000	10.000	10.000	360.000	20.000	30.000	30.000	24
8	30.000	160.000	180.000	180.000	160.000	140.000	130.000	120.000	140.000	140.000	160.000	160.000	24
9	180.000	210.000	170.000	180.000	180.000	190.000	170.000	170.000	180.000	190.000	190.000	220.000	24
10	300.000	310.000	310.000	320.000	320.000	320.000	310.000	310.000	310.000	300.000	310.000	310.000	24
11	340.000	320.000	340.000	310.000	310.000	330.000	320.000	320.000	330.000	330.000	330.000	320.000	24
12	240.000	230.000	220.000	200.000	200.000	200.000	210.000	230.000	230.000	240.000	230.000	240.000	24
13	190.000	190.000	190.000	170.000	20.000	.000	40.000	50.000	80.000	80.000	.000	.000	24
14	20.000	290.000	330.000	340.000	190.000	180.000	180.000	200.000	220.000	210.000	220.000	250.000	24
15	230.000	230.000	190.000	200.000	200.000	190.000	200.000	210.000	220.000	230.000	230.000	220.000	24
16	190.000	180.000	130.000	100.000	100.000	80.000	60.000	60.000	60.000	90.000	70.000	70.000	24
17	50.000	60.000	50.000	50.000	50.000	40.000	60.000	50.000	50.000	40.000	50.000	30.000	24
18	340.000	350.000	340.000	300.000	180.000	180.000	190.000	260.000	270.000	280.000	290.000	240.000	24
19	330.000	310.000	350.000	340.000	330.000	360.000	330.000	330.000	330.000	330.000	310.000	320.000	24
20	50.000	40.000	320.000	10.000	30.000	30.000	10.000	350.000	30.000	10.000	360.000	360.000	24
21	220.000	240.000	220.000	220.000	200.000	190.000	200.000	210.000	210.000	210.000	210.000	210.000	24
22	320.000	340.000	310.000	270.000	320.000	350.000	330.000	330.000	320.000	330.000	330.000	350.000	24
23	320.000	330.000	310.000	330.000	330.000	340.000	360.000	340.000	330.000	340.000	340.000	330.000	24
24	320.000	280.000	280.000	270.000	300.000	300.000	310.000	320.000	320.000	310.000	290.000	250.000	24
N3	31	31	31	31	31	31	31	31	31	31	31	31	

N(1) = HOURS OF VALID DATA
N3 = DAYS WITH VALID HOURLY AVERAGES

TABLE A-9. JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
HANGER 11

TEMPERATURE
WBAN
UNITS= DEGREES F.

	LOCAL TIME											
DAY	0	1	2	3	4	5	6	7	8	9	10	11
24	71.000	75.000	76.000	74.000	73.000	70.000	65.000	68.000	73.000	77.000	77.000	78.000
25	65.000	63.000	62.000	60.000	60.000	60.000	58.000	61.000	63.000	63.000	67.000	69.000
26	60.000	58.000	57.000	56.000	53.000	54.000	54.000	57.000	63.000	66.000	69.000	69.000
27	62.000	62.000	61.000	61.000	63.000	62.000	64.000	65.000	66.000	69.000	72.000	71.000
28	70.000	66.000	63.000	62.000	60.000	57.000	55.000	54.000	53.000	54.000	55.000	57.000
29	53.000	52.000	52.000	53.000	54.000	53.000	54.000	54.000	55.000	57.000	58.000	59.000
30	58.000	57.000	57.000	57.000	57.000	57.000	57.000	57.000	58.000	62.000	62.000	61.000
1	56.000	55.000	55.000	53.000	51.000	50.000	50.000	53.000	59.000	61.000	65.000	66.000
2	58.000	57.000	53.000	53.000	54.000	56.000	57.000	58.000	58.000	59.000	59.000	60.000
3	65.000	65.000	66.000	58.000	59.000	59.000	58.000	58.000	62.000	65.000	67.000	70.000
4	61.000	60.000	59.000	59.000	58.000	58.000	59.000	60.000	62.000	63.000	64.000	69.000
5	62.000	59.000	56.000	55.000	54.000	54.000	52.000	51.000	53.000	52.000	53.000	53.000
6	47.000	45.000	44.000	43.000	41.000	43.000	43.000	44.000	47.000	55.000	57.000	58.000
7	45.000	49.000	49.000	48.000	46.000	44.000	45.000	45.000	49.000	51.000	53.000	55.000
8	45.000	44.000	42.000	43.000	42.000	42.000	41.000	44.000	48.000	52.000	55.000	59.000
9	52.000	52.000	53.000	50.000	50.000	48.000	49.000	49.000	59.000	61.000	60.000	62.000
10	58.000	58.000	53.000	55.000	54.000	50.000	48.000	48.000	50.000	53.000	55.000	55.000
11	41.000	40.000	40.000	39.000	38.000	38.000	37.000	38.000	40.000	45.000	46.000	49.000
12	45.000	40.000	40.000	42.000	38.000	40.000	40.000	44.000	48.000	53.000	57.000	58.000
13	52.000	51.000	51.000	51.000	50.000	49.000	49.000	51.000	54.000	56.000	61.000	60.000
14	51.000	53.000	52.000	51.000	52.000	49.000	48.000	52.000	58.000	62.000	63.000	66.000
15	52.000	52.000	50.000	49.000	48.000	49.000	49.000	49.000	58.000	63.000	68.000	70.000
16	57.000	57.000	56.000	55.000	54.000	53.000	53.000	52.000	57.000	64.000	66.000	74.000
17	63.000	63.000	63.000	63.000	62.000	62.000	62.000	61.000	62.000	63.000	64.000	64.000
18	60.000	59.000	59.000	59.000	58.000	58.000	58.000	59.000	63.000	64.000	66.000	66.000
19	59.000	57.000	57.000	55.000	54.000	55.000	54.000	55.000	61.000	63.000	66.000	63.000
20	49.000	48.000	49.000	49.000	49.000	49.000	49.000	49.000	50.000	50.000	51.000	52.000
21	44.000	43.000	43.000	43.000	43.000	43.000	44.000	44.000	47.000	49.000	52.000	53.000
22	56.000	54.000	53.000	51.000	49.000	48.000	47.000	48.000	52.000	57.000	58.000	61.000
23	45.000	45.000	44.000	44.000	43.000	41.000	41.000	43.000	44.000	47.000	52.000	53.000
24	41.000	40.000	39.000	38.000	37.000	37.000	36.000	36.000	41.000	44.000	47.000	49.000
AVG	54.935	54.161	53.355	52.548	51.742	51.226	50.839	51.839	55.129	58.032	60.097	61.581
N3	31	31	31	31	31	31	31	31	31	31	31	31
M4	71.000	75.000	76.000	74.000	73.000	70.000	65.000	68.000	73.000	77.000	77.000	78.000

N(1) = HOURS OF VALID DATA
MAX(2) = PEAK 1 HOUR CONCENTRATION
N3 = DAYS WITH VALID HOURLY AVERAGES
M4 = PEAK HOURLY AVERAGES

TABLE A-9. JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
(cont'd) HANGER 11

TEMPERATURE
WBAN
UNITS= DEGREES F.

	LOCAL TIME														
DAY	12	13	14	15	16	17	18	19	20	21	22	23	AVG	N(1)	MAX(2)
24	80.000	81.000	81.000	81.000	79.000	78.000	74.000	73.000	71.000	70.000	68.000	67.000	74.167	24	81.000
25	70.000	72.000	72.000	72.000	69.000	68.000	66.000	65.000	58.000	64.000	62.000	62.000	64.625	24	72.000
26	70.000	70.000	72.000	71.000	69.000	67.000	65.000	65.000	64.000	64.000	64.000	64.000	63.375	24	72.000
27	73.000	72.000	72.000	71.000	70.000	69.000	68.000	68.000	68.000	69.000	69.000	70.000	67.375	24	73.000
28	58.000	60.000	60.000	60.000	60.000	57.000	56.000	52.000	53.000	52.000	53.000	53.000	57.500	24	70.000
29	59.000	59.000	60.000	60.000	59.000	60.000	60.000	61.000	62.000	60.000	58.000	58.000	57.083	24	62.000
30	62.000	62.000	61.000	62.000	62.000	62.000	60.000	59.000	58.000	55.000	55.000	55.000	58.875	24	62.000
1	66.000	67.000	67.000	63.000	61.000	60.000	59.000	58.000	58.000	57.000	57.000	57.000	58.500	24	67.000
2	59.000	59.000	59.000	60.000	61.000	62.000	62.000	62.000	62.000	63.000	63.000	64.000	59.083	24	64.000
3	73.000	73.000	74.000	75.000	74.000	72.000	66.000	64.000	63.000	63.000	62.000	61.000	65.500	24	75.000
4	69.000	70.000	69.000	69.000	68.000	68.000	66.000	66.000	65.000	65.000	66.000	64.000	64.042	24	70.000
5	55.000	56.000	55.000	55.000	54.000	54.000	52.000	49.000	49.000	48.000	48.000	47.000	53.125	24	62.000
6	60.000	62.000	62.000	61.000	57.000	55.000	53.000	50.000	50.000	50.000	47.000	46.000	50.833	24	62.000
7	58.000	59.000	55.000	56.000	59.000	56.000	51.000	50.000	48.000	48.000	46.000	45.000	50.417	24	59.000
8	61.000	62.000	59.000	59.000	58.000	55.000	50.000	49.000	52.000	52.000	53.000	52.000	50.792	24	62.000
9	62.000	63.000	61.000	62.000	62.000	60.000	59.000	58.000	58.000	59.000	59.000	58.000	56.917	24	63.000
10	54.000	53.000	55.000	53.000	50.000	48.000	46.000	45.000	44.000	43.000	42.000	42.000	50.500	24	58.000
11	52.000	55.000	56.000	58.000	57.000	55.000	52.000	51.000	49.000	48.000	47.000	46.000	46.542	24	58.000
12	59.000	62.000	62.000	62.000	61.000	59.000	55.000	56.000	55.000	54.000	53.000	52.000	51.458	24	62.000
13	63.000	63.000	64.000	64.000	62.000	61.000	62.000	60.000	56.000	54.000	53.000	54.000	56.292	24	64.000
14	66.000	67.000	68.000	67.000	64.000	61.000	58.000	58.000	57.000	54.000	54.000	53.000	57.667	24	68.000
15	72.000	72.000	69.000	69.000	66.000	64.000	62.000	61.000	60.000	59.000	58.000	57.000	59.417	24	72.000
16	73.000	68.000	67.000	67.000	64.000	63.000	62.000	62.000	63.000	62.000	63.000	63.000	61.542	24	74.000
17	63.000	63.000	63.000	63.000	62.000	61.000	62.000	62.000	61.000	61.000	61.000	60.000	62.250	24	64.000
18	70.000	74.000	75.000	77.000	71.000	66.000	64.000	63.000	64.000	64.000	62.000	59.000	63.792	24	77.000
19	61.000	60.000	58.000	55.000	54.000	53.000	51.000	51.000	50.000	50.000	50.000	49.000	55.875	24	66.000
20	55.000	53.000	54.000	54.000	53.000	52.000	52.000	50.000	49.000	47.000	47.000	45.000	50.208	24	55.000
21	54.000	55.000	56.000	56.000	56.000	54.000	53.000	53.000	53.000	54.000	54.000	55.000	50.042	24	56.000
22	60.000	63.000	59.000	61.000	59.000	55.000	52.000	50.000	48.000	47.000	46.000	46.000	53.333	24	63.000
23	55.000	53.000	52.000	52.000	51.000	49.000	48.000	47.000	45.000	44.000	43.000	42.000	46.792	24	55.000
24	50.000	51.000	52.000	54.000	53.000	50.000	47.000	47.000	47.000	47.000	46.000	46.000	44.792	24	54.000
AVG	62.645	63.161	62.871	62.871	61.516	59.806	57.939	56.935	56.129	55.710	55.129	54.581			
N3	31	31	31	31	31	31	31	31	31	31	31	31			
M4	80.000	81.000	81.000	81.000	79.000	78.000	74.000	73.000	71.000	70.000	69.000	70.000			

N(1) = HOURS OF VALID DATA
MAX(2) = PEAK 1 HOUR CONCENTRATION
N3 = DAYS WITH VALID HOURLY AVERAGES
M4 = PEAK HOURLY AVERAGES

TABLE A-10. JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT HANGER 11

RELATIVE HUMIDITY
WBAN
UNITS= PERCENT

	LOCAL TIME											
DAY	0	1	2	3	4	5	6	7	8	9	10	11
24	81.000	71.000	43.000	34.000	34.000	38.000	59.000	53.000	41.000	33.000	36.000	31.000
25	40.000	43.000	48.000	56.000	58.000	56.000	62.000	58.000	54.000	56.000	47.000	42.000
26	50.000	62.000	67.000	67.000	69.000	69.000	72.000	72.000	58.000	47.000	44.000	46.000
27	78.000	75.000	81.000	84.000	81.000	84.000	75.000	73.000	73.000	68.000	62.000	66.000
28	79.000	59.000	54.000	50.000	54.000	57.000	64.000	77.000	83.000	83.000	80.000	69.000
29	93.000	96.000	100.000	96.000	96.000	96.000	96.000	96.000	96.000	93.000	93.000	93.000
30	93.000	96.000	96.000	96.000	96.000	96.000	96.000	96.000	93.000	81.000	75.000	75.000
1	80.000	80.000	75.000	80.000	86.000	89.000	86.000	80.000	65.000	60.000	54.000	59.000
2	78.000	87.000	93.000	93.000	93.000	87.000	87.000	87.000	90.000	93.000	93.000	93.000
3	100.000	100.000	97.000	81.000	67.000	65.000	67.000	67.000	56.000	47.000	44.000	39.000
4	70.000	72.000	75.000	75.000	78.000	78.000	72.000	78.000	75.000	75.000	75.000	71.000
5	58.000	42.000	44.000	45.000	47.000	43.000	49.000	52.000	53.000	49.000	49.000	44.000
6	56.000	60.000	65.000	69.000	73.000	73.000	63.000	60.000	56.000	47.000	44.000	42.000
7	80.000	59.000	52.000	59.000	63.000	68.000	60.000	63.000	46.000	40.000	35.000	31.000
8	54.000	58.000	63.000	60.000	63.000	65.000	68.000	58.000	52.000	47.000	43.000	35.000
9	69.000	74.000	72.000	83.000	86.000	89.000	89.000	86.000	67.000	52.000	60.000	60.000
10	87.000	65.000	69.000	53.000	47.000	54.000	59.000	56.000	52.000	47.000	42.000	42.000
11	47.000	49.000	49.000	45.000	46.000	46.000	48.000	46.000	45.000	35.000	34.000	30.000
12	44.000	62.000	65.000	58.000	70.000	73.000	73.000	65.000	50.000	41.000	37.000	32.000
13	66.000	66.000	64.000	69.000	74.000	77.000	80.000	77.000	67.000	64.000	56.000	58.000
14	69.000	74.000	74.000	69.000	59.000	66.000	74.000	72.000	55.000	48.000	46.000	40.000
15	90.000	90.000	93.000	89.000	96.000	89.000	93.000	93.000	67.000	52.000	36.000	36.000
16	75.000	72.000	78.000	80.000	83.000	90.000	90.000	90.000	81.000	61.000	61.000	38.000
17	84.000	84.000	87.000	84.000	87.000	90.000	93.000	97.000	93.000	97.000	93.000	90.000
18	90.000	90.000	90.000	87.000	90.000	90.000	90.000	87.000	90.000	81.000	78.000	70.000
19	72.000	78.000	83.000	90.000	86.000	86.000	86.000	86.000	67.000	65.000	59.000	56.000
20	69.000	68.000	66.000	66.000	66.000	66.000	66.000	66.000	64.000	64.000	61.000	59.000
21	83.000	86.000	86.000	86.000	86.000	86.000	86.000	83.000	77.000	66.000	53.000	51.000
22	55.000	62.000	64.000	71.000	80.000	80.000	80.000	66.000	57.000	44.000	42.000	39.000
23	60.000	60.000	63.000	63.000	63.000	68.000	68.000	63.000	60.000	54.000	45.000	41.000
24	55.000	55.000	55.000	55.000	57.000	57.000	62.000	64.000	53.000	47.000	44.000	41.000
AVG	71.129	70.806	71.387	70.710	72.065	73.258	74.613	73.129	65.677	59.258	55.516	52.258
N3	31	31	31	31	31	31	31	31	31	31	31	31
M4	100.000	100.000	100.000	96.000	96.000	96.000	96.000	97.000	96.000	97.000	93.000	93.000

N(1) = HOURS OF VALID DATA
MAX(2) = PEAK 1 HOUR CONCENTRATION
N3 = DAYS WITH VALID HOURLY AVERAGES
M4 = PEAK HOURLY AVERAGES

TABLE A-10. JET AIRCRAFT EXHAUST STUDY SEPT-OCT64 JOHN F. KENNEDY INTERNATIONAL AIRPORT
(cont'd) HANGER 11

RELATIVE HUMIDITY
«BAN
UNITS» PERCENT

	LOCAL TIME														
DAY	12	13	14	15	16	17	18	19	20	21	22	23	AVG	N(1)	MAX(2)
24	31.000	32.000	32.000	33.000	30.000	25.000	29.000	28.000	31.000	29.000	35.000	35.000	30.500	24	81.000
25	36.000	30.000	28.000	28.000	34.000	35.000	36.000	39.000	60.000	41.000	46.000	46.000	44.958	24	62.000
26	41.000	42.000	43.000	46.000	51.000	57.000	63.000	65.000	68.000	68.000	65.000	70.000	58.417	24	72.000
27	66.000	71.000	73.000	76.000	79.000	84.000	87.000	87.000	87.000	81.000	81.000	79.000	77.125	24	87.000
28	70.000	54.000	52.000	48.000	48.000	62.000	67.000	74.000	80.000	86.000	90.000	90.000	68.000	24	90.000
29	93.000	93.000	93.000	93.000	100.000	97.000	97.000	97.000	97.000	97.000	93.000	93.000	95.292	24	100.000
30	73.000	67.000	65.000	60.000	54.000	60.000	62.000	67.000	70.000	77.000	77.000	80.000	74.208	24	96.000
1	61.000	57.000	59.000	65.000	67.000	67.000	72.000	78.000	78.000	83.000	81.000	81.000	72.625	24	89.000
2	97.000	97.000	97.000	97.000	97.000	97.000	97.000	97.000	97.000	97.000	100.000	97.000	93.375	24	100.000
3	28.000	27.000	27.000	25.000	26.000	25.000	51.000	61.000	63.000	60.000	63.000	65.000	56.292	24	100.000
4	73.000	73.000	78.000	78.000	76.000	76.000	73.000	73.000	73.000	73.000	75.000	52.000	72.042	24	78.000
5	40.000	42.000	42.000	39.000	42.000	43.000	47.000	54.000	54.000	59.000	59.000	61.000	49.250	24	61.000
6	39.000	34.000	32.000	39.000	42.000	47.000	51.000	59.000	61.000	69.000	80.000	77.000	59.667	24	80.000
7	29.000	28.000	31.000	30.000	24.000	26.000	32.000	32.000	36.000	39.000	48.000	54.000	44.375	24	80.000
8	35.000	30.000	41.000	48.000	53.000	62.000	74.000	80.000	74.000	72.000	66.000	64.000	56.875	24	80.000
9	63.000	58.000	60.000	63.000	65.000	75.000	81.000	84.000	87.000	87.000	87.000	90.000	74.458	24	90.000
10	40.000	41.000	39.000	34.000	38.000	41.000	39.000	39.000	42.000	40.000	41.000	45.000	48.000	24	87.000
11	25.000	25.000	21.000	21.000	22.000	22.000	27.000	29.000	33.000	34.000	37.000	40.000	35.583	24	49.000
12	35.000	31.000	32.000	46.000	50.000	60.000	64.000	51.000	55.000	57.000	66.000	72.000	53.708	24	73.000
13	52.000	58.000	61.000	68.000	79.000	72.000	43.000	41.000	49.000	55.000	59.000	57.000	63.042	24	80.000
14	40.000	37.000	35.000	40.000	54.000	63.000	75.000	74.000	75.000	83.000	83.000	86.000	62.292	24	86.000
15	38.000	38.000	51.000	51.000	54.000	63.000	67.000	72.000	72.000	75.000	72.000	78.000	68.958	24	96.000
16	48.000	59.000	51.000	44.000	43.000	58.000	63.000	67.000	70.000	78.000	81.000	84.000	68.542	24	90.000
17	93.000	90.000	93.000	93.000	97.000	97.000	93.000	90.000	93.000	90.000	90.000	93.000	91.292	24	97.000
18	64.000	54.000	52.000	48.000	54.000	76.000	75.000	78.000	69.000	58.000	60.000	78.000	75.208	24	90.000
19	60.000	62.000	69.000	75.000	75.000	74.000	77.000	77.000	71.000	71.000	69.000	69.000	73.292	24	90.000
20	55.000	59.000	55.000	55.000	55.000	59.000	59.000	71.000	80.000	83.000	83.000	83.000	65.750	24	83.000
21	47.000	42.000	42.000	42.000	42.000	53.000	57.000	49.000	45.000	53.000	55.000	57.000	63.042	24	86.000
22	38.000	35.000	36.000	34.000	35.000	42.000	45.000	50.000	54.000	54.000	56.000	58.000	53.208	24	80.000
23	30.000	41.000	41.000	43.000	46.000	46.000	54.000	48.000	47.000	49.000	51.000	53.000	52.750	24	68.000
24	38.000	40.000	37.000	35.000	34.000	39.000	44.000	44.000	46.000	48.000	52.000	58.000	48.333	24	64.000
AVG	51.194	49.903	50.452	51.484	54.032	58.161	61.323	63.194	64.935	66.065	67.032	68.645			
N3	31	31	31	31	31	31	31	31	31	31	31	31			
M4	97.000	97.000	97.000	97.000	100.000	97.000	97.000	97.000	97.000	97.000	100.000	97.000			

N(1) = HOURS OF VALID DATA
MAX(2) = PEAK 1 HOUR CONCENTRATION
N3 = DAYS WITH VALID HOURLY AVERAGES
M4 = PEAK HOURLY AVERAGES

SEC 920
(9-64)

Figure A1. ODOR SURVEY OBSERVATION

Location: _____

Grid coordinates: X | Y (cc.1-6)

Pollutant code: 0 4 (cc.7-8)

Date: year | month | day (cc.9-14)

Time	Strength of Odor[a] (0 No odor, 1 Faint, 2 Strong, 3 No observation)	Description of Odor	Odor Code[b]	Observer's Name	Observer Number[b]	Observer's Reaction (None / Pleasant / Not pleasant)	Do you have a cold? (No / Yes)	Rain (No / Yes)
7 A.M. 0 7 (15-16)	0 1 2 3 (17)		(18-19)		(20-22)	0 1 2 (23)	0 1 (24)	0 1 (25)
4 P.M. 1 4								
3 P.M. 2 0								
10 P.M. 2 2								
12 P.M. 2 4								

a Check only 1 box

b Do not use these boxes